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THE

GEOLOGICAL

AND

NATURAL HISTORY SURVEY

OF

MINNESOTA.

THE THIRTEENTH ANNUAL REPORT,

FOR THE YEAR 1884.

N. H. WINCHELL, STATE GEOLOGIST.

Submitted to the President of the University, April 1, 1885.

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1885.

ADDRESS.

THE UNIVERSITY OF MINNESOTA,
MINNEAPOLIS, MINN., April 1, 1885.

To the President of the University,

DEAR SIR: I have the honor to present herewith the thirteenth annual report on the geological and natural history survey. Accompanying this is a copy of the second annual report for reprint, as that report is constantly requested by librarians and geologists who desire to complete their series, and has been out of print for several years.

Very respectfully, your obedient servant,

N. H. WINCHELL,
State geologist and curator of the general museum.

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REPORT.

I.

SUMMARY STATEMENT.

An edition of six hundred copies of the first volume of the final report of the survey was bound and distributed prior to December 1st. If the number bound and ready for distribution had been much larger the edition would have been exhausted immediately. The distribution was made in accordance with the instructions of the secretary of state, as expressed in the following circular, but the number of copies was not large enough to supply all the libraries and institutions contemplated by the instructions:

RULES OF THE SECRETARY OF STATE FOR THE DISTRIBUTION OF THE FINAL REPORT OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

In February, 1881, a bill was introduced in the state senate by Hon. J. B. Gilfillan, which had sundry provisions concerning the printing and distribution of the volumes of the final report of the state geologist on the geological and natural history survey of the state. Although this bill passed the senate it was lost in the house in the last days of the session, from lack of time. It is presumed that had it came to a vote in the house it would have passed, as it was approved unanimously by the senate. It has therefore been adopted and followed as far as possible, in the publication of the first volume of the survey, and

will be in the future, unless the legislature orders otherwise. Section four of this bill reads as follows:

"SEC. 4. The volumes of the final report of said survey, as they may be prepared by the state geologist from time to time, shall be issued in an edition of five thousand copies each, and shall be distributed in the name of the board of regents of the University, under the direction of the state geologist, to scientific and educational institutions, and to individuals as follows:

"To the library of each chartered college and scientific institution in Minnesota, three copies each; to each normal school, three copies; to the libraries of the institute for the deaf and mute, the insane asylums, the state prison, and every public library in the state, not otherwise designated, one copy each; to each county auditor for the use of the county, one copy; to each of the offices in the capitol, one copy; to each member of the board of regents, three copies; to the Historical Society, and to the Minnesota Academy of Sciences, ten copies each; to each newspaper published in the state, one copy; to each senator and representative of the present Legislature, one copy; to the governor and lieutenant governor, each one copy; to each assistant on the survey, who has furnished manuscript or illustrations published in the report, three copies; to other scientists in Minnesota, fifty copies; to the general office of each railroad that has furnished aid to the survey, three copies; to the library of each high school, furnishing students fitted for the freshman class of the State University, one copy; to the state library of each state in the Union, one copy; to each state university and college of agriculture and mechanic arts, one copy; to the geologists and naturalists of other states, two hundred copies; to the library of the University of Minnesota, two hundred copies; to other colleges and scientific institutions in the United States, one hundred copies; to foreign institutions and scientists, one hundred copies; and to the state geologist, twenty-five copies. The remainder shall be deposited in the State University, and shall be sold at such prices as the board of regents may determine; and the proceeds of such sales shall be used by said regents for the purchase of apparatus and books for the survey, and after its completion, for the departments of natural science at the State University."

The only departures from the foregoing, ordered by the secretary of state, consist in the delivery of two hundred copies to

the secretary of state, for distribution to the offices of foreign consuls, and the transmission of the proceeds of all sales to the state treasurer at St. Paul.

The copies remaining after this distribution will be sold at five dollars per copy for the best style, (tinted paper, half roan binding,) and three and a half dollars for the common style, bound in cloth, according to the direction of the executive committee of the board of regents, approved by the secretary of state.

All correspondence should be addressed to

N. H. WINCHELL,
State geologist,
Minneapolis, Minn.

Unless the Legislature orders otherwise it is probable that the rest of the edition, when bound, will be disposed of according to this plan.

From the last week in September to the end of the year the time and energy of the survey was given almost entirely to the work of preparing a suitable exhibit at the World's Cotton and Industrial Exposition at New Orleans. A portion of the accompanying report consists of a description of that exhibit, as prepared, with the permission of the board of regents, under the direction, and mainly at the expense of the Minnesota State Board of Collective Exhibits. From December 1st till January 11th, I was in New Orleans, occupied with the installation of this exhibit. Mr. Upham was also absent on the same work from December 1st till Christmas, and my son H. V. Winchell, who had been casually and temporarily occupied throughout the summer in laboratory and office work of the survey, and continually through the fall on the New Orleans exhibit, was left as permanent custodian of the property. The aggregate value of the articles belonging to this portion of the Minnesota exhibit is about six thousand dollars, as estimated for the placing of insurance.

Mr. C. L. Herrick who was at work on the mammals of the state, and had spent about a year in making original observations thereon, was appointed to a position on the faculty of Denison University, in the state of Ohio, and was released during the fall, and till January 1, 1885, to discharge those duties. He has now, however, resumed work, and will render his final report on this branch of the natural history of the state before the close of the year 1885.

Dr. P. L. Hatch's report on ornithology has not yet been tendered, but it is expected that it will be ready for publication in the early part of the present year.

In order to complete the publication of material already on hand, relating to the geology proper, provision ought to be made, during the legislative session of 1885, for the printing of another volume. This would be largely devoted to a belt of counties in the central portion of the state, and would be of scope and plan similar to volume one.

At the World's Industrial and Cotton Centennial Exposition, now being held at New Orleans, the State of Minnesota for the first time publicly exhibits two new products of her natural resources—salt and iron.

The brine derived from the well at Humbolt, in Kittson county, is an augury of what may be in the future. The brine which overflows at the surface has more than the average per cent of chloride of sodium found in the Michigan brines, while the total solid matter in solution (including chloride of sodium) is only from one-third to one-half as much. The probable geological formation from which this brine issues and the conditions of future successful exploration, are given in the accompanying report. I have to acknowledge the generous assistance of Mr. Valentine, owner of the well, for valuable information and for a series of the drillings from the well.

The year 1884 has witnessed a very extensive and important opening of the iron mines at Vermilion lake. Mr. George C. Stone, of St. Paul, general manager for the Minnesota Iron Company, has given every facility for the examination of the mines, and has supplied information and statistics embraced in the chapter on the Vermilion iron ores. Specimens illustrating the ores of the various mines at Vermilion lake are on exhibition at New Orleans, aggregating in weight about 2,500 pounds. Sixty-two thousand tons were shipped from the mines in the latter part of the season, delivered at Cleveland, Pittsburg and other lower lake ports. This ore ranks well, so far as assays made at the mines indicate, with the ores of the best quality from Michigan. It is believed to be derived from rocks of the same geological horizon as the ores from Marquette and Menominee.

The importance of this development to the state of Minnesota can hardly be overestimated. This is the most westerly point at which the ores of this geological horizon are known to exist. They should not be carried east for smelting and manu-

facture, but should be reduced where they are mined. Their market will for the present be in the east, but their ultimate consumption will be in the west where the settlement and rapid development of the country demand iron for all the appliances into which iron enters. The freightage of the manufactured products directly from Minnesota to supply this western demand will ultimately be seen to be so much cheaper than the carriage of the ores east and the manufactured articles again west, that the ways and means for avoiding this double freightage will be sought and found by the shrewd capitalists of the state. Such articles would compete successfully, in the western markets, with those of eastern manufacture. The coal of Iowa or Illinois would have to take the place of that of Pennsylvania, unless charcoal could be substituted.

II.

RECONNAISSANCES.

(*a*). *Notes of a reconnaissance into Pope county, May*, 1884.

This trip of observation was made at the instance and solicitation of Mr. G. Tharaldson, of Langhei.

The drift. Along the new railroad extending northwestwardly from Minneapolis to St. Cloud are various new and interesting exposures of the drift deposits, which deserve a careful inspection. They exhibit the relations of the gray and red tills, the gray overlying the red and finally prevailing entirely. There are also gravel deposits, and patches of laminated clay. Northwest of this moraine the surface is flat. At once this flat tract is seen to consist of gravel derived from the gray till, containing Cretaceous bits. At Rodgers Siding the country is timbered, and undulating, the till being gray, and very fine.

At the crossing of Crow river the gray till becomes converted into and overlain by a pebbly clay, and then by a finer loess, which last shows ten to fifteen feet in thickness at the first (outer) cuts. There is some gravel and sand considerably tinted with red, indicating the proximity of red till deposits. At a few points a red till is seen at the lower levels. After crossing the river the country is timbered and rolling for about two miles, but the surface consists of this loess, or fine silt without boulders. It then becomes flat or undulating, and the soil rather sandy, though probably a till, and occasionally is red, but mainly gray— especially gray in the upward swells and ridges that are cut by the grade.

Monticello is on a gravel plain but few feet above the river, which is apparently analogous to, if not identical with that on

which St. Cloud is situated, though at the latter point it is apparently about two miles in width.

Red granite is to be seen near the railroad bridge over the Sauk river, near St. Cloud. On crossing the river the grade ascends, apparently, to a higher flat than the St. Cloud flat, which likewise consists of gravel—at least there is no bluff on the east side, but the road runs from the plain directly on to the bridge which is about fifteen feet above the water, while on the west side it enters cuts in gravel bluffs about fifteen feet higher than the grade. With some undulations this gravelly flat continues to St. Joseph, the railroad cuts only showing gravel.

West from St. Joseph the surface becomes broken and rolling, yet consists of gravel. This gravel, however, in the distance of about a mile from Watab creek, in the direction of the railroad, gives place to a red till, even morainic till on the east side, and then also on the west side. This is the condition of the surface at Collegeville. This red till becomes yellowish, verging toward gray, interspersed with tamarack swamps. As a red till, however, it apparently continues to Avon, and to Albany, but with variations to a yellowish color. Just west of Albany a characteristic gray till appears, lying over the red, but is rather pebbly instead of stony, and the surface becomes smooth or gently undulating, and continues so to Freeport. At Melrose this gray till is covered by a loess loam, due apparently, to the former action of Sauk river in the valley of which Melrose is situated. At the crossing of Sauk river, west of Melrose, the bluff cut consists of gray till, 15 feet.

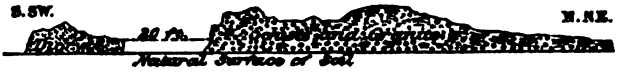
At Sauk Centre, on the diorite rock, situated about half a mile southeast from the railroad station, the glaciation runs 42° east of south (true meridian).

Crystalline rocks at Sauk Centre. This is a dark speckled rock consisting almost entirely of hornblende and feldspar, the relations of which to the red granite lying adjacent, are hid by drift. The red granite is about 20 feet distant (north) from the dioryte. The dioryte resembles that at "the point," at Little Falls, in having, over part of its upper surface, where planed by glaciation, the alternating lines of predominating feldspar with predominating hornblende, causing an appearance as of lamination, or at least a coarse gneissic structure. Except this, and some jointage planes, it is homogeneous and massive, and is exposed over an area of about a square rod. At several places, extending for forty rods further southeast, on land of Mr. Gates, this

dioryte is found in outcrop, and has been quarried. It is here a jointed, angular, firm rock, the same as at the point on Mr. Carl's land, described. It shows milky-opaque quartz, visible to the unaided eye, though no quartz can be thus discerned in it at Mr. Carl's. It disintegrates more rapidly than the granite. While it appears, in bulk, massive, it has frequent joints running in all directions, facilitating the rude methods of quarrying that have been pursued. The outward aspect of the general surface is much like that of some disintegrated portions of the Duluth gabbro range.

The adjacent red granite, which might be called gneiss, has about ten times as much area of exposed surface as the foregoing. It encloses bands and patches of mica schist. It has an abundance of evident quartz, and some of the orthoclase crystals are two and a half inches in diameter, especially when, somewhat in the manner of veins, the red granite interpenetrates and cuts across, the schists. Sometimes it runs in vanishing narrow seams coincident with the schistose direction, and sometimes it cuts boldly across it, the schists then having apparently an angular, fractured termination. This mica schist is firm, quartzose, and occasionally green as if with epidote, and would, in many places, properly be styled a gneiss. Its structure runs 60° east of north (true mer.), and is nearly vertical, but in some cases is at a small angle (two or three degrees) with a perpendicular, the dip being toward the south. At another point this structure, which stands about vertical, runs north, 88° east (true mer.). It is here disturbed by a network of veins of the red granite, and becomes exceedingly firm and dark colored, being really a dark gneiss. In the most of this mica schist hornblende is more abundant than mica, the former constituting the bulk of the dark ingredient, and the latter appearing at the planes of easy separation.

Fig. 1.



It is only in the southern part of this red granite that it has any involved dark schists or gneiss, and the nearest part is twenty feet from the foregoing dioryte. If there be a superposition, as indicated by the slope of the upper surfaces, the dioryte lies under the granite. (See figure 1.)

No. 858. Average sample of the red granite.
No. 859. Average sample of the hard, dark schist, or gneiss.
No. 860. A sample of the schist showing considerable mica.
No. 861. Average sample of the massive dioryte.

At another small area of exposed red granite about thirty rods further northwest, the enclosed area of schist strikes east and west, and dips toward the south, at an angle of about 15° from a perpendicular. Here also the general slope of the outcrop is a glaciated dome with a gentle slope toward the north-northeast, and a steep one west-southwest, rising about two and a half feet. At several places in the village, and especially on the land of Mr. Carl, the rock is found but few feet under the surface.

Mr. Carl sells stone at one dollar per cord, and lets the quarry to parties who work it. They sell for eight or ten dollars per cord.

Flouring mills at Sauk Centre. The *McClure Roller Mills* are owned by the McClure estate, and are run by water power in Sauk river. The fall is 11½ feet, aided by a dam which sets water back several miles. The mills have two Kindelberger wheels, of 48 and 35 inches diameter, producing respectively about 68 and 40 horse power. There are six sets of corrugated (Noye) rollers, and three sets of smooth rolls, with two stone buhrs for flour; the capacity of the mills being 175 barrels in 24 hours.

Artificial mounds. Near the county line between Stearns and Pope counties, along the valley of Ashley creek, are a great many artificial mounds of earth. They are on the north side of the railroad accompanying a marshy tract. The railroad passes up an old valley of glacial drainage, abundantly strewn with gravel, and these mounds are frequent along this valley. Near a school house in the valley granite outcrops are visible. This is a short distance east of Westport, and where Ashley creek receives a tributary from the south. There is another more remarkable mound situated at the point where the railroad passes between lakes Amelia and Turtle, at the western extremity of the gravel ridge on which the railroad runs between the lakes; which is so large that it can hardly be artificial. Indeed it appears more like a flat-topped remnant of an old terrace. It rises about 20 feet above the lakes, and about 15 feet above the rest of the country. It is on the north side of the railroad, and about three-fourths of a mile in diameter.

Twenty or more other artificial mounds are on the land of Dan.

F. Bartke, S. W. ¼ sec. 2, T. 125, 38, a short distance west of Glenwood. One in this vicinity is known as *White Bear mound.* This rises about 200 feet above the lake, but is situated on a natural conical hill. This is on the north side of the lake, about three miles from Glenwood. Numerous other mounds are on the low land, southwest of the White Bear mound, on the north side of Pelican lake; also north of White Bear mound, and northwesterly, scattered over the upland prairie.

Minnewaska lake. This lake, according to statements of citizens of Glenwood, was originally designated by an Indian name, meaning *Dish lake,* because of its being in a low basin. After that, when the chief, White Bear, was buried in a high hill on the north shore, it was called *White Bear lake.* After a time it was changed to *lake Whipple,* from bishop Whipple, of Faribault, and by act of the state Legislature of 1883 it was again changed to *Minnewaska,* or Good-water. It is said to be 85 feet deep in its deepest part, and averages about forty feet, and there is no known evidence of its having ever stood at a higher level.

This lake basin, which is also known, facetiously, as the "Pope county cellar," seems, to one approaching it from the east by way of the St. Paul, Minneapolis and Manitoba Railway, as he first views it from the railroad station, like some grand excavation in the rocky formation of the country. The smooth, high prairie, which, as a gravel-strewn plain, extends monotonously northeastward from the east end of the lake, breaks off rather suddenly toward the west in a remarkable depression of about 240 feet, and in this depression the expanse of the lake appears. There has been discovered, however, no rock bed in any of its bluffs, which consist, everywhere, of drift materials only.

A limestone mass, lying among the drift hills N. E. ¼ sec. 18, T. 125, 37, owned by Mrs. Sarah Peterson, in the upper part of the bluffs that enclose the lake, was suspected to be an outcrop of the native beds, and was so reputed. It was carefully examined. Its strata are nearly horizontal dipping N. W. about 2 degrees, and on excavation in front it maintains a perpendicular face as far as dug, developing a thickness of at least 5½ feet. With a probe it was found to run under the soil, southward, about 9 feet., but beyond that the probe passes too deep without striking it to allow of its being continuous *in situ.* On lower ground, in the vicinity of this limestone mass, are several large boulders of coarse, red granite, some being ten feet in diameter. About the shores of the lake are occasionally found bits of Cretaceous

lignite. It was stated that one man found a piece as large as he could carry. It *seems* to come from below the water, since it is said to appear after heavy storms.

The drift bluffs at the east end of the lake, have an average hight, as measured by aneroid, of 248 feet above the level of the lake, but some of the hills adjacent rise about 25 feet higher. These hills, and the general flat surface extending northeastwardly, are composed superficially, and largely of gravel and sand. The effect of winds and storms on this deposit has been to uncover and make superficial numerous transported boulders, especially throughout that part which has a broken contour. Thus the apparent abundance of boulders, large as it is in the original, in comparison with that of boulders in ordinary till, is superficially much increased. They are innumerable, some of them being two or three feet in diameter. In some places they literally cover the surface with a continuous pavement. These bluffs appear rough and hilly just at the lake, and between the station and the lake. From their summits the prairie level, flat or moderately undulating, is maintained eastward; but toward the northwest the surface is rough and stony, exhibiting the characters of a glacial moraine, extending to the south of lake Reno.

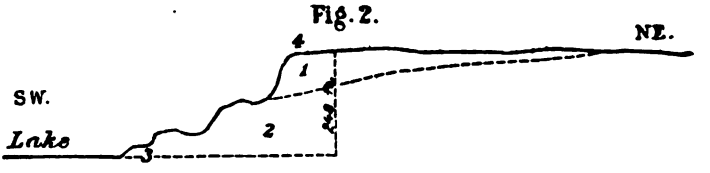
Below this covering of gray gravel, which seems to be 50 to 75 feet thick, these bluffs are composed of gray till. This is evinced by the composition of exposed cuts and slides in the frequent ravines. This underlying till sheds the water that penetrates downward in the gravel, causing numerous springs which are found at about the same horizon in the bluffs, all about the east end of the lake. The spring waters gather into little creeks, and one of these was caused to run a small flouring mill till a few years ago. The village of Glenwood is supplied with excellent water by a pipe running beneath the surface of the ground from an artificial reservoir in which several of these springs are concentrated, one hundred and forty feet above the village. The resultant pressure is sufficient to throw a stream from the hydrants in the streets, over any of the houses of the village.

The high bluffs which appear at the east end of the lake are not so conspicuous further west. They insensibly diminish, and descend finally to the "outlet," where the general level is but a few feet higher than the lake itself. In the same manner the south shore descends toward the west.

Between the tops of the hills, at the railroad station, and the

undulating or rolling surface on which Glenwood village is situated, a distance of about a mile, are curious knolls, more or less elongated, of gray, or yellow, till, rising in the midst of a general till area. The general contour of the bluff at the east end of this lake is shown by figure 2.

Fig. 2.



Explanation of Figure 2.

1. Gray gravel and sand, with many stones and boulders.
2. Yellow till, with few stones and boulders.
3. Place of Glenwood village.
4. Place of Glenwood station.

The moraine which passes along the east end of lake Minnewaska is from one-half to three-quarter mile distant from the lake, and extends N. W. from Glenwood. It is characterized, at one and two miles north of the station, by more numerous granite boulders, strewn over the tops of the knolls, among them being some of limestone. The country three miles northwest is rough, even very rough, some of the hillocks rising 100 feet higher than the station. Lake Reno is said to be forty feet higher than the railroad station at Glenwood. East from the station the surface becomes smooth, but shows a very slight eastward decline, for at least a distance of about two miles. From Glenwood the line seems to pass more southerly, into Barsness.

Springs. Allusion has already been made to the singular and persistent spring-course along these bluffs, reminding the beholder of the similar effect of the green shales of the Trenton in Fillmore and other counties in forming a line of springs near the tops of the St. Peter bluffs in those counties.* These springs afford a strongly calcareous water, and in favorable positions deposit a copious sediment of tufa. Such deposits are found on S. W. ¼ sec. 2, T. 125, 38, on the land of Daniel F. Bartke, and on that of Stillman Ayers. It is here deposited on growing moss and leaves, and lies at 100 to 150 feet above the lake. The water is shed by the underlying clayey till. In similar circumstances

*Final report, vol. 1, p. 274.

are found local beds of peat, maintained on the face of the bluff below such springs. Some of the water, on flowing again through the bog becomes sulphuretted, and similar to that of Mr. Bryan near Minnesota City, in Winona county.

Another source of springs, apparently below the clay, gives chalybeate water. This source gives origin to the springs that issue at much lower levels along some of the larger creeks that cut the bluffs in the same vicinity. They are distinct from the lime-depositing springs.

Brick are made at Glenwood by John Aiton. They are of a light red, or yellow-red color, and sell for ten dollars per thousand. Mr. Aiton also burns quicklime, from boulders gathered on the surface.

Mills. There are three mills on the Chippewa that serve the farmers of southeastern Pope county, viz.: *Swift Falls mill*, Marlue mill and West's mill. The first is a roller mill, but the others are stone mills, with three run in each.

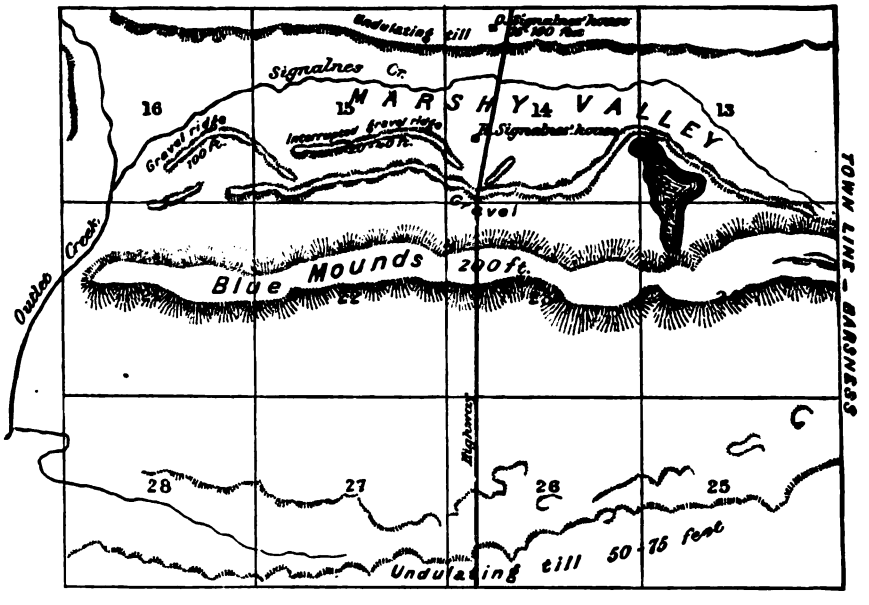
Trees. The native trees of southern Pope county are as follows: Bur oak, bass, elm, ironwood, aspen, white ash, plum, box-elder, willow, sugar maple, balm of Gilead (in Langhei), black ash, juneberry, red elm, cottonwood, black cherry, hackberry — no black oak, nor white oak.

The Blue Mounds, a remarkable ridge of drift materials running through the southern portions of Blue Mounds and Barsness townships, a portion of which is illustrated by the accompanying sketch-map (Fig. 3) has been described by Mr. Upham in the eighth annual report.* This ridge, where sketched, consists essentially of the coarser drift materials, gravel and sand predominating, overstrewn and intermingled with boulders. The pebbles are some of them from the Cupriferous, such as dark amygdaloids, melaphyr, epidote and quartz, and numerous greenstones. But the most of the larger stones are granite and hornblendic schists, with Winnipeg limestone. The bulk of the entire range seems to be gravel and sand, as evinced by the great depth of some of the depressions which only rarely contain any water and by little cuts along the roadside. It is a distinct, and almost a simple, range. Along its north side in the valley of Signalnes creek it is flanked by a subordinate parallel range rising about half as high as the main range. This range is also composed of gravel and sand. It is interrupted, sometimes

* Eight report, p. 78.

double, and presents all the characters of a glacial kame. It runs into and blends with the main range on the town line of Barsness, where it seems to contribute its contents to that range, causing the highest point in the whole series, so far as seen, in this vicinity. Toward the west the Blue Mounds are lost in crossing

Fig. 3.



the valley of Outlet creek, or the valley which Signalnes creek occupies, for Outlet creek comes through drift, and has approximate bluffs till it enters the Signalnes valley.

On each side of the Blue Mounds range is a distinct valley, that on the north side being bounded abruptly on the north by a bench or bluff of till, rising from 75 to a 100 feet. That on the south is also bounded on the south by an undulating ascent of gray till, which, within a quarter of a mile, reaches the height of 50 to 75 feet above the valley. The northern valley is occupied by Signalnes creek, but the southern valley has no distinct line of superficial drainage except at its western termination where, through section 28, a little creek is formed which works westwardly toward lake Emily. The ridge itself, where crossed by the highway in section 23, is not more that 80 rods across, and its hight is about 200 feet.

Toward the south further the till surface continues to rise, and becomes approximately flat or smoothly undulating, within a mile. In section 1, Langhei, next the Rolling Fork township line, the elevation is 1,347 feet, as determined by aneroid under favorable circumstances, the connection being made with Benson station which is 1,042 feet above mean tide.

From the high land in Langhei the "blue mounds" appear lower than the moraine at Glenwood, and with a glass the former can be seen running along eastward into Barsness as an isolated single ridge, the distant moraine being seen over it.

According to Mr. G. Thasaldson the Blue Mounds consist entirely of sand at the point where the highway from Glenwood to Benson crosses them, which is about three miles east of the point above described. The same was stated by Mr. Signalnes. Mr. Upham also describes mount Tom, in Colfax, Kandiyohi county, as composed of coarse drift materials, largely gravel and sand, this hill being in the supposed eastward extension of the "blue mounds."

As to the origin and nature of this ridge of gravel and sand, it presents all the characters of a glacial kame; but its gigantic proportions, if of that nature, would make it rank among the largest ever described in this country, since, according to Mr. Upham, it can be traced distinctly for a distance of about forty miles. Mr. Upham has, besides, regarded it rather as a terminal moraine, produced by ice moving in a northeasterly direction. While it seems necessary to give this ridge further examination, with special reference to the nature of its contents, its actual width, continuity and location, before its origin can be considered understood, there are some surrounding facts, and theoretical considerations, which indicate strongly that this range of drift hills is more of the nature of a kame, due to the action of an immense glacial river, in glacial times, than of that of a terminal moraine formed by glacier ice. The same facts and considerations would also indicate that the "Dovre moraine," in Kandiyohi county, is another great kame of gravel and sand.

The flat country at Benson, which is sandy and rather poor for wheat, extends several miles in width east and west. It is due to the former action of the Chippewa river, which now runs but little below the general level, and which formerly must have spread widely over the country, spreading sand and sandy clay. This sandy loam is twenty-two feet thick at Benson. All wells get water at the bottom of it, on the clay.

(*b*) *Notes of a trip across the Mesabi range to Vermilion lake.*

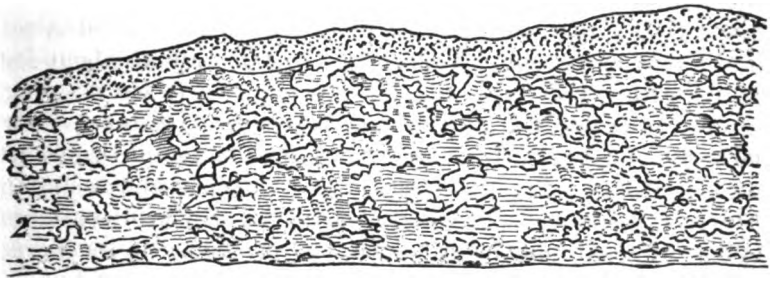
This excursion was made for the purpose of obtaining samples of the Vermilion ore, for exhibition at the World's Industrial and Cotton Centennial Exposition, at New Orleans. A few observations of geological interest were also made.

Surface features. First — There are two belts of morainic accumulations noticeable between the lake Superior shore and Vermilion lake. One is south of the crossing of the Cloquet river, about twenty miles from Two Harbors (Agate bay, of the previous reports); the second is from two to five miles north of the crossing of the St. Louis river. This is remarkable, not for the hight of the hills of which it is composed, as they are from ten to thirty feet high; but for their composition and their abrupt, and marked, and distinct outlines. These hills and ridges are short and sharp, and appear to consist very largely of boulders of gray gabbro, the till being gray and stony. On the north side of the former of these moraines, on both sides of the Cloquet river, the surface is smooth, and consists of gravel and sand, clothed with Banks' pine. These flats extend to the Wisacode, but they become swampy. After passing the Wisacode are seen occasional low ridges and knolls with white pine and birch, but cedar and tamarack elsewhere prevail, with extensive peat bogs. At the crossing of the St. Louis there is no deep valley, only a shallow one on drift and boulders, eight or ten feet deep. Timber mainly spruce and tamarack, even on the higher portions. Soil good, loamy, rather darker than the till below, but showing no black loam like that on the prairies. The soil at the moraine a few miles north of the St. Louis crossing, what there is of it, is very good, the subsoil being gray till; but largely made up of boulders. White pine abundant. After passing the sharp ridges of this second moraine the country seems to become converted to a vast "muskeg," or peat bog, with similar low boulder-knolls occasionally seen. These muskegs seem to lie on the summit of the great gabbro range from Duluth, and extend over a width of six to ten miles at least from the moraine mentioned a few miles north of the St. Louis river, to and beyond the Partridge river, which is nothing more than a general ditch in the great muskeg. North from Okwanim, and particularly at a point about eight miles south of the crossing of the Embarras, the surface is gravel-strewn, and smooth to undulating. This gravel consists almost wholly of shingle from the quartzites and slates of the

Animikie group. At the crossing of the Embarras the country is swampy, but has a good soil and is habitable and arable on both sides of the river.

Second—A common feature of the drift, seen in the cuts along the railroad, is represented by the following figure—Fig. 4. The upper portion of the drift, for a thickness of four to six feet, consists of pebbly till, but little stony (1), and the underlying till (2) is very stony, large boulders appearing all over the surface of the cuts. The upper deposit is of nearly the same color as the lower. The till in general, while of a reddish cast, has also a tendency to gray in deep cuts, and to a darker, more umber-like red in the upper deposit.

Fig. 4.



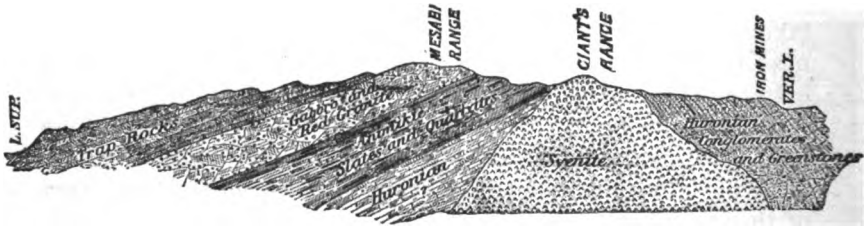
Third—There are two rock ranges, or Mesabis, passed by the railroad between Two Harbors and Vermilion lake, and the name "Mesabi" has been applied to each of them, without distinction. The more southern one is that formed by the gabbro belt running from Duluth northeastwardly to the international boundary, passing south of Gunflint and Mountain lakes, and constituting the actual water-divide between North and South lakes on the international boundary. This includes the high land of the "Mesabi iron ranges," as well as the iron locations at Mayhew lake north of Grand Marais. It is that which which has been most frequently mentioned as "the Mesabi," especially along its eastern extension where it is more distinct and abrupt, particularly from the north, than it is further west. This range of high land always appears *as a range*, from the north, and it operates more powerfully to control the drainage of the northeastern part of the state than the other Mesabi, lying further north. It is,

however, broad as well as high, and holds on its summit some of the largest lakes of this part of the state, Brule lake being one. It is characterized by bare rock, alternating with peat bogs, and muskegs with scattered and stunted spruces. This range should continue to be known as *the Mesabi.* Its width is sometimes fifteen miles, but generally from four to six; and in most places, especially north from Grand Marais, and south from Ogishke Muncie lake, its rounded low crest is distinct, and narrowed to less than a mile. The Duluth & Iron Range railroad crosses this belt of gabbro, as shown by outcrops of the rock, between the St. Louis river crossing and the station of Okwanim. It is also likely that the gabbro rock extends further south, though entirely hid by drift materials.

The other range which has been named *Mesabi* consists of gray granite, or syenite, and it is known also as the *Giant's Range.* It runs along parallel with the former, distant from it from five to fifteen miles. It is a distinct, narrow ridge rising about 200 feet above the average level on either side. It is intersected at several places by streams. It is crossed by the railroad about four miles north of Okwanim, and is less than a mile in width, though granite outcrops (red granite) may be seen at a distance of two miles still further north. This range, with more or less distinctness, continues northeastward to the international boundary which it crosses north of Gunflint lake. It is much less important as a topographic feature, and less persistent in its characters as a range, than the gabbro Mesabi and it should not be confounded with it in future use of the term Mesabi. The survey reports will refer to this as the *Giant's Range*, by which name it is also known in the reports of the Canadian survey, on the north side of the international boundary.

The stratigraphy of the crystalline rocks in the district of northeastern Minnesota, so far as it is indicated by observations of this reconnaissance, is generalized by the following diagram.

Fig. 5.



In passing upward from Two Harbors there are very few exposures, the only ones seen between the station and the crossing of the St. Louis river being within a few miles of the lake shore and consisting of the ordinary greenish "trap" of the Cupriferous. Soon after crossing the St. Louis river there are outcrops of massive, gray gabbro, the same as at Rice's point, near Duluth, and these continue to, and perhaps a little distance north of, the station called Okwanim. Thence northward the surface slopes northward and is strewn with debris of slate, undistinguishable from the slates that have been described along the international boundary, and called Animikie slates; but there is but one place along the railroad at which there is any exposure of rock. This is at the "red pan cut," about two miles north of Okwanim, where a very red and irony outcrop appears extending only about 20 feet. The opportunity for examination was not sufficient to determine the nature of this rock, but the aspect and topography, as well as the geographic position, are sufficient to indicate the horizon of the iron bearing beds of the Mesabi range proper, as described in the report for 1880, or the base of the Animikie group. The gravel which is strewn over the country along here has a considerable quantity of jasper and quartzyte, often nearly black. It continues to the granitic range already referred to as the Giant's range. This rock is massive and rises from 75 to 100 feet higher than the grade. The aneroid showed the station at the summit, as the road passes over the range, to be 155 feet higher than the station at the mines at Tower. The gray syenite composing the Giant's Range is replaced by red at a few cuts by the railroad on the north side of the range, extending for a distance of two miles, at least. For some distance further north, and until after crossing the Embarras river, no rock appears, but at a distance of about 12 miles from the station at the mines at Tower is an exposure of a purplish, aphanitic, hard rock, showing a sedimentary structure that dips toward the north about 75 degrees. The same direction of dip continues at all exposures from there to Vermilion lake, so far as observed. The rock itself is greenish, massive, magnesian, or greenish slaty, and schistose, some of it being like the rock of the ridges between the Northern Pacific Junction and Knife falls. The following diagram is not only based on these observations, but expresses in general the whole that is known of the rocky structure at any point going northward from Lake Superior.

At the mines of the Minnesota Iron Company the rock consists largely of jasper and a magnesian schist, dipping north at an angle of 85°—88°. This magnesian rock is ordinarily green, but in the vicinity of the mines it becomes more and more ferruginous and apparently is changed to iron ore—a soft red hematite. At the same time there are conglomeratic portions, as well as arenaceous. These latter are more abundant on the slope to Vermillion lake, north of the mines. The ore consists, in general, of hematite, but there are also small amounts of non-titaniferous magnetite, and small crystals of gœthite.

Stratigraphic position of the iron ores of northern Minnesota. There seem to be three horizons in the strata that, in northeastern Minnesota, have attracted attention for their iron bearing quality.

First—The titanic iron of the gabbro belt. This includes the iron ore of the Mayhew location north of Grand Marais, the so-called iron ore of Duluth and Herman, and the iron ore that has been reported on Poplar river. This furnishes the iron sand of the lake Superior beach. This horizon of iron ore seems to have no parallels, so far as reported, in Michigan and Wisconsin.

Second—The iron ore of the Mesabi range. This is hard hematite and non-titaniferous magnetite. It is that examined in towns 59.14, and 60.14, and is presumably the cause of the iron ore signs in that tract of country between Okwanim and the Giant's range. It is in the horizon of the Animikie slates, and near the bottom of the same, and the probable parallel of the Commonwealth mines in Wisconsin, without any known equivalants in Michigan.

Third—The hematite of the Vermilion mines at Vermilion lake. This is on the north side of the granite belt, and in rocks dipping north, the other two horizons being on the south side, in rocks dipping south. This iron horizon is lower, in the strata, than either of the others, and seems to be on the horizon of the Marquette and Menominee iron ores, as is also indicated by the associated quartzytes, jaspers, and conglomerates.

III.

THE VERMILION IRON ORES.

The year 1884 having witnessed the opening of the first active mining in the state, its bearing upon the future of this industry, and its importance as a matter of history, both demand of the survey a presentation of the whole matter as full and explicit as the present opportunity may afford. The following facts have been obtained mainly of the officers of the company, and can be accepted as a faithful statement of the present condition and extent of this important new industry.

In every instance where the ore was tried by actual furnace tests, it has proved its superior quality. The company are mining at the rate of 15,000 tons per month, employing at the mines 400 men, but could easily increase their product to 25,000 or 30,000 tons per month.

The buildings, machinery and plant at the mines involved an outlay of fully $300,000, and the ore docks at Two Harbors fully $200,000 more. The whole amount expended, including the building and equipment of the Duluth and Iron Range railroad (sixty-eight miles, from Two Harbors to Tower), by the Minnesota Iron Company in this enterprise is over $2,500,000.

The Vermilion lake iron district, of which the Minnesota Iron Company are proprietors, lies in the south half of township 62 north, in range 15 west, in St. Louis county, Minnesota. The greater portion of the northern half of the township is occupied by lake Vermilion.

The whole of that portion of the township which lies south of lake Vermilion belongs to the Minnesota Iron Company, excepting section 36, which is a school section. This section is in the

southeastern corner of the township, and is not known to contain any iron.

The shipping port on lake Superior for the ores of this district is Two Harbors, formerly known as Agate and Burlington bays (25 miles northeast of Duluth), which affords unusual natural advantages for the erection of ore piers and for safety and convenience of vessels of the largest class. The surveyed line of the Duluth & Iron Range railroad, between the town of Tower, at Vermilion lake, and Two Harbors, is 72 miles in length, with easy grades and curves, and offering no unusual difficulties of construction. The building of this line was done under contract by John S. Wolf & Co., Ottumwa, Ia., well known and energetic railroad builders. The line was ready for the transportation of ore by Aug. 1, 1884. This line will be at once extended to Duluth, and there placed in connection with the railroad system of the United States. The Duluth & Iron Range Railroad company have also built ore piers and made the harbor improvements at Two Harbors under the supervision of Mr. George H. White who built the ore piers at Escanaba. These piers are five feet higher than those at Escanaba and seven feet higher than those at Marquette, thus affording the best possible facilities for loading the largest vessels in the trade.

A general similarity may be observed between the Vermilion lake iron district, in township 62, range 15, and the district in the now celebrated township 47, range 27, in Marquette county, Michigan, which includes the well known Jackson, Cleveland, Lake Superior, New York, and Barnum mines, besides many others of less notoriety.

The Vermilion lake deposits, however, appear to be much larger, as far as first-class ore is concerned, than the mines in township 47, range 27, in Marquette county. The district has been examined by persons who were familiar with all the mines of Marquette county in their earliest stages, among others, Hon. Edward Breitung and Mr. Samuel P. Ely, who are among the pioneers of the Marquette district, and Mr. John N. Armstrong, the veteran Marquette and Menomonee range explorer. In their opinion the quantity of first-class ore now exposed at Vermillion lake exceeds what was exposed of that grade of ore at the same stage of development in all the mines of Marquette county. It is reasonably probable that the mines in township 62, range 15, will, in the natural order of their development, after a reasonable time, yield as much of the highest grade ore

as the mines of township 47, range 27, in Marquette county, with the Humboldt, Champion, Michigamme, and Republic ranges added.

A brief account of the results of the company's explorations thus far will substantiate this statement; although these explorations, by reason of the shortness of the time which has elapsed since the discovery of the deposits and the difficulty of getting in supplies in advance of roads or settlements, have necessarily been partial and imperfect. The most striking and natural exposures only have thus far been named and examined, which will be described in the order of their occurrence, beginning at the most eastern.

The Stuntz mine, in the northeast quarter of the southeast quarter of section 27, township 62, range 15, lies on the north side of a valley between the north and south ranges. By making a rock cutting of about 75 feet, which would be principally through the slates which adjoin the ore on the south side, a face of 75 feet could be obtained for the commencement of mining operations. The surface stripping shows a with of about 25 feet of ore for about 400 feet in length. The stripping westward was stopped by a spring hole and wet ground; there was, however, no reason to suppose that the ore terminated at that point; on the contrary there is a reasonable probability of its continuance westward. The ore is a coarse-grained red specular ore with a good lustre, much resembling the bright Republic ore of Marquette county. The belt is almost entirely pure, needing very little assorting.

The Stone mine, about an eighth of a mile west of the Stuntz, has an elevation of 25 feet above it. At the most eastern end is exposed a narrow belt of slate ore of excellent quality, which appears to be a lens lying in front, or south, of the main deposit. The main deposit is a very large one, of a close grained red specular ore of great purity, much resembling some of the best ores in the lake Superior mine in Marquette county. At the eastern end, so far as now developed, it is about 50 feet in width, gradually increasing, for 300 feet westward, to 62 feet in width and maintaining a width of 46 feet at 700 feet westward.

This body of ore, at its present stage of surface developement, in respect to the combination of size, continuous extent, and great purity, stands without a parallel in the United States up to the present time. Thus far in all the trenches, test-pits, and stripping, there has not been exposed any mixed ore whatever.

	Metallic iron.	Silica.	Phosphorus.
Analysis of surface specimens from this mine made by the Isabella Furnace Co. gave.....	68.34	2.14	.053
Another by the Pittsburgh Bessemer Steele Co. gave.....	68.19	2.02	.061
Another of numerous small pieces taken from every part of the surface by Mr. S. P. Ely gave.	69.30	.....	.059

The Ely mine, west half of the southeast quarter of section 27. This mine includes the extension of the Stone mine westward from the point above described together with a separate deposit lying some 300 feet northwest of the Stone mine. But little surface work has been done at this deposit; although it lies at an elevation of about 20 feet above the Stone mine, the conformation of the adjoining rock occasions more or less wet ground, and it has not yet been convenient to drain the surface, which can be done, however, with little difficulty. This deposit appears to be about 100 feet in width; knobs and projections of pure ore rise above the surface at various points, indicating a large and good deposit. Its dimensions and characteristics cannot be given with the same certainty as in the case of the other mines described, because the surface has not been stripped or trenched for the reasons which have been stated. The ore is of the best quality, however, and the deposit is obviously a large one. From the first of March to the present time more ore has been discovered, both in the Tower and the Stone (in fact in every mine) than was ever known here at the time of the explorations of Chester and Wright.

The Tower mine, east half of the southwest quarter of section 27, is the most elevated deposit on either of the ore ranges. It includes, in fact, two, and perhaps three, distinct mines. The most southern of these deposits is clearly distinct from either of the others; it lies on the line of the Stone and Ely mines, protracted westward, and is probably a continuance of that deposit. The trenches show a width of about 18 feet of clean ore of the best quality. One hundred and fifty feet west of the trench which shows 18 feet of ore is a new discovery which shows clean ore for 150 feet wide. The two more northerly deposits are separated from each other by a jasper "hog's back" about 50 feet in width, and it cannot yet be determined whether they are really separate deposits, or whether they become one again in extension. There are some indications that they become one, and that the Ely mine is an extension eastward of the united deposit.

One of them shows a width of 33 feet and the other of 42 feet of clean ore of the best quality. There has not yet been time and opportunity positively to determine the length of the extension of these bodies westward; but from the lay of the ground there is no doubt of such an extension as will make as large a mine as either of the others.

The Armstrong mine, northwest quarter, section 27. This deposit lies on the northern slope of the Tower range. Two distinct deposits have been discovered here; one of the veins is 15 and the other 30 feet wide, of good ore. Their extent and relation to the other mines of the company have not yet been determined. The deposits of the district are so large and so numerous and have extended over so much territory, that there has not been time thus far to get more than a partial knowledge of them. It is quite possible that the Armstrong may prove to be an extension of the West Breitung, which is described further on.

The Breitung mine, west half southwest quarter, sec. 27, and east half southeast quarter, section 28. The main deposit at this mine furnishes a larger natural exposure of pure ore than either of the others. The natural outcropping before any work was done was about 38 feet in width, 35 in hight, and 75 feet in length, all of the purest ore. Subsequent work shows that at 250 feet east of the outcrop, the deposit is 95 feet wide. Between these points a slide of jasper has covered a portion of the vein for about 30 feet in width for a depth of from three to seven feet; otherwise than this, the ore is continuous to this point, 250 feet eastward. Here the stripping became rather heavy and was discontinued; but at a point 300 feet further eastward, on what is believed to be a continuance of the same deposit, trenches 100 feet apart showed 35 and 38 feet of the same ore with no mixture of rock.

The southern deposit of the Breitung mine lies about 125 feet south of the one just described, upon slightly lower ground. A belt of chloritic schist lies between the two.

This vein has been exposed at four different points; at the most easterly it is 27 feet wide and 100 feet in length, stripped; at the next one it shows about 10 feet in width; at the third, 15 feet, and at the most easterly, 18 feet. The distance between the extreme openings is about 1,000 feet; and there is no doubt that the vein is continuous for that distance. This ore is also of excellent quality.

About 175 feet north of west of the main deposit lies the *West Beitung*. Here has been exposed, for a length of 80 feet, a vein of ore for upwards of 50 feet in width. At that width the stripping became rather heavy and work was stopped for a time, although the limit of the ore had not been reached. This deposit has two jasper walls and is entirely distinct from the other one.

The main deposit of the Breitung mine is a bright, handsome ore, free from any admixture of rock, and can be mined (as can the ore of the Stone mine) of 67 per cent purity without assorting. An analysis made by the Isabella Furnace Company of samples from all parts of a stock pile of 2,500 tons

	Metallic iron.	Silica.	Phosphorus.
gave	68.79	1.34	.038
Another, made by the Pittsburgh Bessemer Steel Co., gave	68.19	1.41	.041
Another, of numerous small pieces taken by Mr. S. P. Ely, from all parts of the deposit, gave	68.51	.....	.078

The Lee mine, north half section 33. This is a very large deposit, or rather group of deposits, upon the South range. It includes three distinct ore bodies. The most northerly is nearly or quite 100 feet in width at the point where it was first exposed. The explorations upon this deposit show its continuity, with varying widths, for about 500 feet, and the indications of the formation point to its protraction for nearly 2,000 feet farther westward.

On the highest point of the South Range, about 75 feet south of the deposit just described, a vein some ten feet wide has been uncovered, which rapidly widens as it descends.

A third ore body lies 75 feet farther south and is 36 feet wide This vein extends 700 feet to the eastward, as far as now developed, and is also probably protracted westward, as mentioned just above in respect to the first deposit. The group of deposits which constitute the Lee mine contain extremely large bodies of pure ore; and, so far as any mixed ore is found, it is not, comparatively to the pure ore, in greater quantity nor more difficult of assortment, than in the best of the Marquette county mines. An analysis of the mixed ore from this mine, selected as such by Mr. S. P. Ely, gave 61.59 metallic iron. The following are the analyses of the pure ore from this location :

	Metallic iron.	Silica.	Phosphorus.
Isabella Furnace Co	66.42	4.67	.031
Pittsburgh Bessemer Steel Co	66.37	4.72	.039
S. P. Ely's samples, from all parts of the mine	67.80	.....	.053

The Minnesota Iron Company intend to place a sufficient quantity of their ore in market at lower lake ports in the autumn of 1884 to make it known to consumers, and thereafter to produce as much as the market may require of the highest grade of ore, up to an amount equal to, or greater than, the Marquette county product of that kind of ore. As a matter of course, an unlimited amount of ore cannot be produced in a single year, and some years of development and organization of the business must pass before the full productive capacity of these mines can be reached. It will be observed that all the Vermilion lake ore is sufficiently low in phosphorus for Bessemer use, and that a practically unlimited supply of such ore can be obtained, which is also of the highest standard in metallic iron.

The existence of such ore bodies is a fact of almost national importance, and their speedy exploitation is of the greatest interest to the whole iron-producing industry west of the Alleghanies.

The policy of the Minnesota Iron Company will be to ship only the best ores. Such mixed ores or soft hematites as may be developed in the course of its mining, will be for sale at the mine for those who may require them; but the company's own product and shipments will be confined to the ores of the highest grade. Lake transportation will not be materially higher than that from Marquette to lower lake ports, by reason of the large and increasing quantity of coal which is seeking transportation to the head of lake Superior, which will give a remunerative up freight to the ore vessels.

The rapid growth and development of several of the mines in Michigan is exhibited by the following table, showing the product of the five largest mines of Marquette county, Michigan, during the last ten years.

PRODUCT OF FIVE MINES OF MARQUETTE COUNTY, MICH., FOR TEN YEARS, ENDING IN 1882,

IN GROSS TONS.

	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	Total for ten years.
Jackson mine	130,131	105,600	90,568	98,480	80,340	83,121	103,219	120,620	118,939	96,830	1,027,848
Cleveland mine	133,265	105,858	129,881	146,393	152,188	152,737	131,167	212,748	198,569	206,120	1,568,926
Lake Superior mine	158,078	114,074	129,339	111,766	127,349	109,674	173,938	204,094	262,235	296,509	1,687,056
Champion mine	72,782	47,097	56,877	66,002	70,883	73,464	94,027	112,401	145,427	159,009	897,969
Republic mine	105,453	122,639	119,726	120,095	165 839	176,221	135,231	235,387	233,786	235,109	1,649,486
	599,709	495,268	526,391	542,736	596,599	595,217	637,582	885,250	958,956	993,577	6,831,285

The probable productive duration of iron ore deposits of this character is a question in respect to which some valuable experience has been gained in working the Marquette deposits. The following table shows the aggregate production of the five Marquette county mines which have been before cited, from their first opening to the present time:

	Total production in gross tons.
Jackson mine	2,291,992
Cleveland mine	2,535,184
Lake Superior mine	2,962,965
Champion mine	1,134,912
Republic mine	1,660,508
	10,585,561

The Jackson, Cleveland, and lake Superior mines have been worked continuously since 1858, the Champion mine since 1868, and the Republic mine since 1872. Notwithstanding their large product, all of them excepting the Jackson, have as much, or more, ore in sight and as great a future product in prospect, as at any time in their history.

TABLE OF ANALYSES OF HARD HEMATITE IRON ORES

FROM THE

MINNESOTA IRON COMPANY'S MINES

IN THE VERMILION IRON DISTRICT,

VICINITY OF TOWER, ST. LOUIS COUNTY, MINN.

AUTHORITY.	Metallic Iron.	Silica.	Sulphur.	Phosphorus.
J. Blodgett Britton, Philadelphia, March, 1880, select samples	69.69	.....	.....	.019
Prof. Albert H. Chester, Clinton, N. Y., October, 1880, samples taken by himself from all parts of north belt	66.93	3.39	.01	.011
Samples taken by himself from all parts of south belt	66.43	3.89	none	.006
North Chicago Rolling Mill, Nov. 18, 1880, duplicates of Prof. Chester's selection, north belt	65.22	3.45	none	.064
North Chicago Rolling Mill, south belt	66.18	3.75	none	.039
Chas. E. Wright, Marquette, Mich., Sept. 1, 1881, samples taken by himself from every part of north belt	66.71	2.40	.018	.072
Do. Do. south belt	67.60	1.35	.009	.027
Isabella Furnace, Etna, Allegheny Co., Pa., Oct. 20, 1882, samples from all parts of a stock pile of 2,500 tons at the "Breitung" mine, north belt	68.79	1.34	.....	.038
Isabella Furnace, samples from the "Stone" mine, north belt	68.34	2.14	.....	.053
Isabella Furnace, surface samples from the "Lee" mine, south belt	66.42	4.67	.....	.031
Pittsburgh Bessemer Steel Co., Nov. 10, 1882, samples from all parts of a stock pile of 2,500 tons at the "Breitung" mine	68.51	1.41	.....	.041
Pittsburgh Bessemer Steel Co., surface samples from "Stone" mine	68.19	2.02	.....	.061
Pittsburgh Bessemer Steel Co., surface samples from "Lee" mine	66.37	4.72	.....	.039
J. Blodgett Britton, Philadelphia, Dec. 20, 1882, sample of slate ore from the "Stone" mine	69.93	.73	.....	.033
Average samples taken from all parts of the "Lee" mine, by S. P. Ely, January, 1883, analyzed by Chas. E. Wright	67.80	.....	.....	.053

Average samples taken from all parts of the "Stone" mine, by S. P. Ely, January, 1883, analyzed by Chas. E. Wright.....	69.30	.....	.....	.059
Average samples taken from all parts of the "Breitung" mine, by S. P. Ely, January, 1883, analyzed by Chas. E. Wright..	68.51	.....	.....	.078

The foregoing are all hard hematite specular ores, and are all the analyses that have been made of the ores of the district above named since the Minnesota Iron Company commenced its exploration in 1879, excepting a single one of mixed ore from the "Lee" mine, selected as such by Mr. S. P. Ely, which has been mentioned in the foregoing pages.

Besides the land in township 62, range 15, which has been mentioned, the Minnesota Iron Company own several thousand acres in the adjoining township on the east, township 62, range 14, selected to cover any extension eastward of the Vermilion lake range, and also several thousand acres along the line of the Duluth & Iron Range railroad, and 3,000 acres at Two Harbors on lake Superior; making in all 22,488 acres.

Shipments in 1884. During the short season of 1884, after the completion of the Duluth and Iron Range railroad, and the construction of the necessary docks at Two Harbors, the products of the Vermilion mines amounted to about 1,000 tons per day, the aggregate product being 62,000 tons, distributed to various furnaces and iron works in Ohio, Pennsylvania, and Virginia.

RECENT ANALYSES OF THE VERMILION IRON ORES.

ST. PAUL, MINN., March 6th, 1885.

Prof. N. H. Winchell,
State geologist, Minneapolis, Minn.,

DEAR SIR: As I promised you, I give you below eight late analyses of our ore:

Metallic iron.	Phosphorus.	Silica.	Metallic iron.	Phosphorus.	Silica.
66.70	.042	3.71	69.27	.044	.084
68.37	.060	1.56	67.75	.051	2.07
65.65	.036	5.48	67.84	.061	1.77
66.94	.031	3.65	67.02	.051	1.75

Yours Truly,
GEORGE C. STONE, Gen'l manager.

IV.

THE CRYSTALLINE ROCKS OF MINNESOTA.

There is a series of gneisses and soft red granites, or more properly, syenites, associated with the gabbro belt in the northeastern part of the state. This red granite, or "red rock," as it has been styled in earlier reports, is believed to be due to metamorphism of sediments that had been deposited at a date but slightly prior to the outflow of the gabbro itself; and, as it has been seen to pass into subcrystalline rock and quartz porphyry, and, as similar or identical quartz-porphyry and felsite are formed when in immediate association with masses of red granite and of gabbro, interstratified with the igneous outflows of the cupriferous, this red granite has hitherto been believed to belong in the age of the cupriferous, and for the same reason the gabbro has been accepted as the basal igneous rock of the cupriferous. The cupriferous overlies the Animikie slates and quartzites; and the great igneous capping of the Animikie hills along the international boundary, from Gunflint lake to Pigeon point, is in the direct line of extension of the gabbro range. This belt of syenites and granites, with the gabbro, disappears at the west end of lake Superior, beneath the waters of the lake and of the St. Louis valley. Further southwest, and in the line of their extension, however, are outcrops of red and gray granite, on the Rum river, south of Mille Lacs, on the Mississippi river between Clearwater and Watab, and on the Minnesota river between New Ulm and the foot of Big Stone lake. The granite rocks that appear in the Mississippi valley are not lithologically similar to those of this series, while those of the Minnesota valley are more nearly identical with them. There is an outcrop of the basal igneous rocks of the Cupriferous at Taylors Falls, overlain uncomformably by some of the Cambrian (probably the Calciferous

period), indicating that the strike of these granite rocks is further south than the outcrops on the Rum and Minnesota rivers.

Still, whether these upper Mississippi granites be the analogues of the red granites north of Lake Superior, or not, those that appear at New Ulm, as they underlie a conglomerate and red quartzite, have a greater degree of probability of being on the same horizon, and exhibit also a greater lithological resemblance. In any case the gabbro is entirely lost sight of. As an outcropping, overflowing rock, the gabbro may be considered, perhaps, to have had a more intense effect as a metamorphosing agent, but one less extensive geographically, than was the effect of those forces which made possible and necessary that outflow, when acting over a broader area without actual fracturing of the crust. Thus, perhaps, the metamorphism of the strata immediately preceding the age of the gabbro outflow, may have been more profound toward the southwest further, where no gabbro is found. In apparent consonance with this, the crystalline rocks, which might be in the extension of those slates and quartzites underlying the gabbro, are found to occupy a wider belt where they cross the Minnesota valley than where they are associated with the outflow of igneous rock in northeastern Minnesota. Their prevailing schistose structure, dipping toward the southeast, if it be due to original sedimentation, is in harmony with the known strike of the red syenites northeast from Duluth. This dip seems to be changed to northwest at the foot of Big Stone lake, indicating that the Minnesota valley passes over an anticlinal in these rocks, extending from Big Stone lake to the red granite outcrop near New Ulm.

Lying toward the north of the belt of red granites of northeastern Minnesota, is a series of schists and slates, containing the iron ores of the Mesabi, and of Vermilion lake. The subdivisions of this series, so far as they can be indicated at this time, are three, viz.: (1). Slates and quartzites, with beds of dioryte (Animikie group), which, in their extension toward the southwest, would, under the foregoing hypothesis, embrace the dioryte-bearing mica schists at Little Falls, Pike Rapids, and Sauk Centre, as well as the dark carbonaceous slates of the St. Louis valley at Knife portage; and finally become the schistose granites of the Minnesota valley anticlinal. (2). Soft, greenish, slaty schists, which hold lenticular masses of light-colored protogine gneiss, and also beds of dioryte. The horizon of the Vermilion iron mines is thought to be near the bottom of this sub-

division, or at the top of the next, but on the opposite side of a Laurentian axis, dipping north, and that of the Mesabi iron range, in the foregoing subdivision, dipping south. (3). Conglomeritic and quartzitic slates, which become fine, arenaceous quartzites, and also embrace beds of siliceous marble.

Still further north, and having a strike in the same N. E. to s. w. direction, is another range of crystalline rocks, forming a conspicuous feature both in the topography and in the geology of that part of the state. The rocks of this horizon, accepted now as the Laurentian of the Canadian geologists, consist of gneiss and syenite, mainly of a light, gray color, but also becoming red. The "Giant's range" of hills is formed by this rock. They enter the state at Saganaga lake, north of Gunflint lake, and with more or less distinctness continue southwestward crossing the Duluth and Iron Range railroad at "Messaba Heights," and the Embarras river at Squagamaw lakes. Toward the west further this range has not been traced out by the survey, but, judging from all the facts and evidences that can be gathered from other sources, this belt of Laurentian turns more westerly, passing through the north central part of the state, and swings northwesterly along the west side of the Lake of the Woods, reappearing on the east side of lake Winnipeg.

On the north side of this Laurentian axis are other crystalline rocks, occupying nearly all the remaining area of the state, outcropping along the Rainy lake river, in the Lake of the Woods, and east of Rainy lake. These seem to be alternating bands of schists and gneiss, and their extent and nature have not been ascertained.

V.

ADDITIONAL ROCK-SAMPLES NUMBERED.

The last recorded number of this series is given in the Tenth Annual Report, page 122.

No. 837. Fragments from 195 feet under Minneapolis; red quartzyte, from the deep well at the Washburn "C." mill.

No. 838. Brick-red quartzyte, from Redstone, near New Ulm.

No. 839. Fine-grained gray syenite from Sauk Rapids, Museum Register No. 4466.

No. 840. Fine-grained gray syenite, like the last from East St. Cloud, Museum Register No. 2128.

No. 841. Granite from near (north of) Motley, Museum Register No. 2596.

No. 842. Greenish syenite (1) from secs. 17 and 18, Ashley. Museum Register No. 4499.

No. 843. Dyke in the Motley syenite. Museum Register No. 2593.

No. 844. Dyke in the Motley syenite, very fine-grained. Museum Register No. 2595.

No. 845. Dyke in the granite at Sauk Rapids. Museum Register No. 2122.

No. 846. Amygdaloidal dyke rock, Maine Prairie. Museum Register No. 2123.

No. 847. Slate, fine-grained, showing sedimentary structure and slaty cleavage running in different directions, crossing each other. Museum Register No. 2681.

No. 848. Fine gray quartzyte, at least a fragmental rock though containing other minerals besides quartz, glistening with fine sparkles on a freshly fractured surface, from Little Falls. Museum Register No. 2690.

No. 849. Staurolite mica schist, Pike Rapids, near the mouth of Swan river. Museum Register No. 2689.

No. 850. Fine crypto-crystalline form of the red-rock, at Duluth, of a reddish brown color; the same as No. 42, but fresher, and less granular.

No. 851. Red granite, from Courtland, Nicollet County, opposite New Ulm.

No. 852. Conglomerate (Potsdam) Courtland, Nicollet County, opposite New Ulm.

No. 852. A. B. C. D. E. F. Pebbles from 852.

No. 853. Pyritiferous red granite, from Mannheim's silver mine, Duluth.

No. 853 A. Vein rock from Mannheim's silver mine, Duluth.

No. 853 B. Vein rock (calcite) from Mannheim's silver mine, Duluth.

No. 854. Traprock from Taylor's Falls, containing metallic copper in minute particles.

No. 855. Dark concretions from the slates at Thomson, thought by Hunt & Dawson to contain a keratose sponge.

No. 856. Vein in gabbro, at Rice's point.

No. 857. Conglomerate of shale in white sand-rock, Fond du Lac.

No. 858. Average samples of the red syenite (micaceous) at Sauk Centre, quarry of T. Carl.

No. 859. Average sample of the hard, dark schist, or gneiss, Sauk Centre, quarry of T. Carl.

No. 860. Sample of the schist showing considerable mica, Sauk Centre.

No. 861. Average sample of the massive dioryte, Sauk Centre. This is the same as described by Streng in the eleventh annual report, page 72, and by Upham on page 103.

These rocks from Sauk Centre are described on page 12.

No. 862. Pinkish, white quartzyte, Garden Valley, seven miles from Merrillan, Jackson County, Wis.; probably shows Irving's "deposited quartz." It is also probably from this that Whitfield's *Palæacmæa Irvingi* was obtained. See Vol. IV, p. 173, *Geology of Wisconsin*.

No. 863. St. Peter sandstone, from the small island in the Minnesota bottom-lands near Fort Snelling, cemented with iron and ("deposited"?) silica, so as to be hard and show different colors.

VI.

THE HUMBOLT SALT WELL IN KITTSON COUNTY.*

It has been known for many years that copious salt springs existed in the valley of the Red river of the North. From their abundance several streams have been named, as Salt river, and "Rivierè Salé." Some of these springs are in Dakota, some in Minnesota, and others, probably the most numerous and copious, are in Manitoba. Some of the earliest French explorers, notably Sieur Du Luth, mentions the fact that the Indians exhibited salt which they said had been obtained in the vicinity of certain lakes in the western prairies, said to be fifteen or twenty days travel further west.

Prof. Henry Youle Hind, in his report on the Assiniboine and Saskatchewan exploring expedition, in 1859, has summarized the principal facts respecting these springs and the salt deposits of the valley of the Red river of the North. They had been made known in Dakota and Minnesota by Prof. Keating in 1823, who accompanied Major Long to the "Sources of the St. Peter's river and lake Winnipeg." At that early date five hundred dollars had been made by a single individual from the sale of salt manufactured in one summer near Pembina. The country was so permanently and extensively saline that the characteristic *Salicornia herbacea* was found growing abundantly in its natural wild state, the only inland locality known west of the Onandaga salt springs, in New York. In 1859 the manufacture of salt from springs in Manitoba was carried on profitably for the Hudson's bay company, at Swan river and at Winnipegosis lake, the methods of manufacture being of the rudest kind.

South of the international boundary several deep wells have

* Read at the Philadelphia meeting (1884) of the American Association for the Advancement of Science.

been sunk within a few years for the purpose of getting a supply of water for stock and farming purposes. Some of these have given an artesian overflow of brine. The first of this kind in Minnesota was sunk at St. Vincent, which is on the Red river of the North at the crossing of the international boundary. This well was 165 feet deep, and only penetrated the drift deposits, the greatest thickness being taken up with a fine lacustrine clay, 112 feet in perpendicular thickness. Under this was found to be coarse gravel and sand which afforded a copious overflow of salt water. This water was not carefully analyzed, though Dr. Perley, at Fort Pembina, made tests sufficient to show it was a brine principally of chloride of sodium, but contained a considerable quantity of magnesium and calcium.

Recently another well has been sunk on the Valentine farm, at Humboldt, about six miles southeast from St. Vincent, on the line of the St. Paul, Minneapolis & Manitoba railway. This also gives a strong salt water, which rises under natural hydrostatic pressure several feet above the ground. The water is clear, and effervesces slightly on exposure to the air and the removal of the pressure.

The section penetrated by this well was the same as that at St. Vincent, but extends much deeper. The salt water was found to rise first from a bed of gravel and sand at a depth of 165 feet, but in small quantity. Between 170 feet and 180 feet, the flow of brine became very copious, rising from a coarse gravel and sand pertaining to the drift. The object of the well being to obtain water for the use of the farm, the drill was sunk deeper. It at once entered a dolomitic limestone, which was found to be 295 feet thick. This has a grain and color like that which is known as the St. Lawrence limestone in the Mississippi river bluffs. Beneath this was found a saccharoidal, siliceous sandstone of rounded grains of quartz, that still furnished a flow of salt water, which rose with still greater force. The drill then entered greenish and reddish shales, some of these being of a reddish-umber color. Fragments from the pumpings show this shale is slightly unctuous, gritless, and compactly impervious, resembling the red shale which has been penetrated in a number of deep wells in the state, and been found to have a great thickness; notably the well at Mankato in the Minnesota valley. While this shale, as shale, is impervious, it is interbedded with red sandstone, particularly in its upper portion, and from these beds of sandstone may rise an artesian flow of fresh water. At the time of my visit it had been entered but forty-six feet.

Mr. C. F. Sidener, of the university of Minnesota, analyzed this brine, and has reported the following composition of the soluble mineral ingredients:

	Grains per gal.
Silica	12.15
Aluminum oxide	2.38
Carbonate of iron	1.08
Calcium sulphate	116.08
Calcium chloride	156.55
Magnesium Sulphate	71.12
Magnesium carbonate	78.60
Magnesium chloride	91.44
Potassium chloride	42.26
Sodium chloride	2764.99
Total mineral ingredients	3336.65

Of the mineral ingredients this gives 82.8 per cent chloride of sodium, the rest being largely made up of the earthy chlorides of calcium and magnesium, and the sulphate of lime. This gives it more than the average per cent of chloride of sodium found in the Michigan brines, while the total solid matter in solution is only from one-third to one-half as much.

There is an interesting question presented by these salt springs and deep wells, of the Red river valley, viz.: From what formation does the brine issue primarily? Professor Hind inferred, from the great predominance of the salt springs over the rocks of the Devonian age, along the southwesterly side of lakes Winnipegosis and Manitoba, that the brine issues from the rocks of the Devonian. He rather discourages the expectation of carboniferous strata in the region explored by him, saying that "it appears tolerably certain that the carboniferous series is not represented in the only locality where it may be looked for with much chance of success." Sir Roderick Murchison, however, in his address before the Royal Geographical Society, on the results of the "Palliser expedition," distinctly states that it is definitely settled that in the western portion of the Saskatchewan valley the Devonian rocks are overlain by carboniferous strata. It seems reasonable to infer that these carboniferous strata extend far enough southeasterly to occupy the unobserved interval of four hundred feet of strata, stretched over a space of ten miles in breadth, "between the salt springs south of Dauphin lake, and the outcrop of the cretaceous shales on the flanks of Riding moun-

tain."* The gypseous and salt-bearing formation of Michigan might occupy this interval. That the salt water issues from near the summit of the Devonian, if from the Devonian at all, is admitted by Professor Hind. In order to issue thus along the summit of the Devonian outcrop, it must be confined in some superior basin. Professor Hind also brought home a specimen of *productus*, which had been given him by a half-breed, who had extracted it from "solid rock;" but he is disposed to discredit the authenticity of this reported "solid rock," and to refer the fossil to some boulder transported from the south by floods and ice in the Red river, although Mr. Billings, who examined it, says that "there seems to be evidence of the existence of at least a portion of the Carboniferous system in this region." The salt-bearing beds of the Carboniferous in the state of Michigan have since been brought to light, and they yield that state a very important source of wealth. Had this fact been known by Professor Hind, it seems to me he would not so summarily have dismissed the idea of Carboniferous salt-bearing strata, and all other Carboniferous strata so plainly indicated by the single specimen of *productus*.

The horizon from which the brine issues at Humboldt appears to be in the Cambrian. It seems to pervade several geological horizons, from the summit of the Devonian downward to the Potsdam — but only superficially, the original source being higher than the Devonian. It is confined by the overlying sheet of impervious clay of which the drift mainly consists in the Red River Valley, and is held under hydrostatic pressure by the downward pressing fresh waters that enter the same pervious gravel-and-sand stratum at higher levels toward the east, south and west. Where the salt springs occur it finds escape to the surface through openings in the clay-sheet. These springs seem to be most frequent and copious in Manitoba, along a belt of country running east and west, where, for some reason, the drift-sheet is much less thick than it is further south. That brine so pure and so strong should be found at so great a distance, both stratigraphically and geographically from its source, indicates the purity and strength of the brine in its native strata.

It remains for the future to determine whether these salt deposits shall become economically of importance to the Northwest. It is certainly the dictate of wisdom to give them a thor-

*Reports of Progress, together with a preliminary and general report on the Assiniboine and Saskatchewan Exploring Expedition. Original edition, quarto, p. 175. Henry Youle Hind.

ough examination and a fair trial. If these brines originate in Carboniferous strata that strike through the base of Riding Mountain, they can easily be discovered in their native place. If those strata exist in that locality the strongest brine would naturally be found by sinking wells into them at some point further toward the south and southwest.

A sample of salt made from this well was exhibited at the New Orleans Industrial and Cotton Centennial Exposition, this being the first ever made from brine native to the state of Minnesota. It was furnished by Mr. Valentine.

Section of the Humbolt Salt Well.

This well is on the line of the St. Paul, Minneapolis & Manitoba railroad, near St. Vincent, in Kittson county, S. ½ of sec. 23, T. 163, 50, five miles east of the Red river of the North, and four and a half miles south of the international boundary. It is seven feet above the highest known flood stage of the river, *i. e.* for ten years.

1. Soil (8–12 inches black)	4 feet.
2. Lacustrine clay, with lime concretions, appertaining to lake Agassiz. In this is found good surface water, and many wells stop in it. It is somewhat pervious to water, so much so that it sometimes allows free entrance of good water. It is very fine and can hardly be called sand, though it is probably the same as called sand at the Lockhart farm	4–16 feet.
3. The same deposit as the last, but more impervious, hence more moist, darker colored, gritless, and thought to be (wrongly) the cause of foul water. This is very slippery, rather darker than can be called "blue clay," yet is apparently a downward continuation of the last	16–140 feet.
4. Pebbly blue till; salt water at 165 feet in small quantity	140–160 feet.
5. Drift gravel and sand, supplying an abundant discharge of salt water, flowing over the surface. This is mainly a gray sand, but contains drift pebbles as large as an inch, mainly of limestone	170–180 feet.
6. Dolomitic limestone, of a grain and texture like the lower magnesian of southeastern Minnesota, in fragments obtained by driving a pipe into the drilled hole; of a buff color	180–190 feet.
7. Powder, of the color of the last; effervesces in NO_5; supposed to be the drillings obtained from the same rock at greater depth; very fine and unidentifiable by the naked eye	190–300 feet.

8. Powder, effervescing rapidly, containing some fine fragments of a compact fine-grained limerock of a slightly reddish cast..... 300-400 feet.

9. Fine drillings of a reddish limerock of shale, with some grains of white quartz. When washed the grains are seen to be mainly of limestone..... 400-475 feet.

10. Reddish sand, of rounded quartz grains. The flow of salt water increased..... 475-500 feet.

11. White sand, of rounded quartz grains. Flow of water still further increased..... 500-532 feet.

12. Faintly reddish quartz sand, in rounded grains..... 532-546 feet.

13. "Soapstone" shale, slippery, red and green, apparently in some alternation, the only representatives of this being in masses of powdered rock and fragments that adhered to the sides of the drill. When washed the grains consist of reddish and gray, or grayish-green shale with considerable white sand..... 546-550 feet.

14. The same in condition of wet paste, having a dark gray color..... 550-556 feet.

15. The same, reddish-brown, or umber-brown..... 556-560 feet.

16. The same, brown, but containing grains of a white mineral which in the air turns to a white powder. It effervesces in nitric acid..... 560-571 feet.

17. The same, but having a more liberal intermixture of a green color, so as to be in general considerably lighter. When washed this shows many bits of dark green shale, and also some of brown, as well as white sand..... 571-592 feet.

18. Greenish-gray shale, the same as No. 13..... 592-610 feet.

19. Greenish shale, containing bits of grayish quartzyte that feebly effervesce in hydrochloric acid. This is unwashed..... 610-635 feet.

20. The same unwashed..... 635-638 feet.

21. Washed grains consisting mainly of rounded quartz (from above), angular, opaque, gray quartz, freshly fractured, and numerous scales and masses of mica. It appears as if the rock here struck is a greenish-gray, foliated, micaceous quartz-schist..... 638-639 feet.

22. Washed drillings, consisting mainly of bits of angular quartz (some, however, are rounded, probably from above), black mica scales, and angular grains of flesh-colored orthoclase, and a white feldspar, evidently one of the Laurentian granites as seen at the Lake of the Woods..... 639-641 feet.

23. The same, but cut much finer, and showing rarely a greenish scale as if of talc..... 641-644 feet.

The boring ceased at 644 feet.

Other deep wells in the valley of the Red river of the North.

Further information respecting artesian and other deep wells in the northwestern part of the state, and particularly in the valley of the Red river of the North, is contained in the sixth

annual report, in the eighth annual report (page 113), in the ninth annual report (page 166), in the eleventh annual report (page 146), and in the following letter from Mr. Springer Harbaugh:

ST. PAUL, MINN., March 20, 1885.

Prof. N. H. Winchell, State Geologist of Minnesota:

DEAR SIR: You have asked me to give my experience regarding artesian wells in the Red River valley, as well as other matters that have come under my observation in this comparatively new and undeveloped country. I will gladly comply with your request, and if I can impart any information that will be of interest to your constituency, or the country generally, I will be indeed gratified in so doing. We commenced our first farming operations on the Keystone farms, located in Polk county, Minn., and on the Lockhart farms, located in Norman county, Minn., in the spring of 1880. The first matter that demanded our attention was to find water for the large amount of stock required in our operations. We sunk and curbed at both places several wells to the depth of from forty to sixty feet, and found an inexhaustible supply of water in all of them. In some of the wells the water came up to within a few feet of the top, and at first it was sweet and good, but after a few days' standing it became so obnoxious that it was not fit for man or beast to drink. We then conceived the idea of drilling down a greater distance and casing with six-inch pipe. Our first effort was made at the Lockhart farms, in 1880. After reaching a depth of about one hundred and sixty feet we struck an extraordinarily heavy flow of water, apparently sufficient to propel a mill with one set of burrs. At a distance it had the appearance of a monument thirty or forty feet high. During the winter of 1880–81 the pipe of this well became filled up with gravel and sand and stopped flowing. We endeavored to clean it out in the spring of 1881, but the well driller lost his drill in the pipe and it became so imbedded in the sand and gravel near the bottom that he was unable to extract it with his inadequate appliances, and we drilled another well a short distance from the first and struck water at about the same distance down, of large flow, but not so heavy as our first well, and which still keeps up a regular and undiminished supply, which we have carried into our buildings

through pipes, and thus we have a great abundance of water of the purest character for all domestic purposes. Fearing that we might again have trouble and possibly the pipe again become obstructed, we subsequently drilled another well at our Lockhart farm headquarters about seven hundred feet distant from our first well, and struck water at about the depth of one hundred and thirty-seven feet, and the flow and pressure was alarmingly heavy. Within twenty-four hours the water found vent alongside the pipe, making a large hole and fairly boiling up in such large and alarming quantities that we soon became inundated, and we at once concentrated a large force of ditchers from St. Paul and the neighboring towns, and constructed ditches several miles to the west, to carry off the surplus water. After, say a couple of weeks, this heavy flow somewhat ceased, and has since been principally confined to the pipe with only a moderate and controllable quantity coming to the surface outside the pipe. This flow through the pipe is still heavy and strong, and could be carried through hose to the highest points of most any building. We sunk other wells on this farm, and cased with three-inch pipe, and have quite heavy flows of pure, semi-soft water. At the Keystone farms, in town 152, range 48, during and since 1881 we have drilled eight artesian wells, and they all have regular, continuous flows of pure, good, semi-soft water. With our first wells we used six-inch pipe, then three-inch pipe, and subsequently two-inch, which we regard sufficiently heavy for farm use. We struck water on this farm at from ninety-five to one hundred and twenty feet, with one exception, where we reached water at one hundred and fifty feet. At one point of this farm where the land is elevated about five feet above the surrounding country, we drilled several test wells and found brackish artesian water at the depth of ninety feet, which we abandoned. We then determined to drill considerably deeper, and struck a pretty heavy artesian flow of milky, brackish tasting water, at the depth of two hundred and fifty feet, which we immediately abandoned, and then selected a point on lower ground, 1,200 feet distant, and found good artesian water at about the depth of one hundred feet. We have now eleven good and satisfactory artesian wells on both farms. In drilling these wells we penetrated through strata of earth about as follows: First through the usual black loam from one and a half to three feet in depth; then through a lightish clay marl from five to seven feet in depth; then through a blue clay varying from thirty to sixty feet in

depth; then a stratum of hard pan; then sand, and finally gravel, when water is generally struck. Between these strata we generally passed through intermediate seams of quicksand and also seams of gravel. I will at this point state that the light clay marl, as well as the blue clay, appears to be fully impregnated and mixed with all the chemical and fertilizing elements requisite to produce the peculiar kind and quality of grain that is becoming so valuable and necessary for human food. I claim that our subsoils are strong and valuable fertilizers. The blue clay when first brought up is pliable, greasy, and of a puttyish nature, and when exposed to the air and dried it makes a valuable dressing for the land. It is, therefore, fair to suppose that we have our fertilizing elements immediately under us for all time to come, and which gives inestimable value to the lands of the Red River Valley and our Northwestern country. I am advised that the farmers of Clay, Norman, and Polk counties are sinking a great many wells, and have generally been successful in obtaining good artesian flows of pure water.

Before closing this communication I beg leave to call your attention to the matter of natural gas, which, as you are aware, is attracting the attention of the people of Western Pennsylvania, West Virginia, and Northeastern Ohio, and working such a marvelous revolution in utilizing it for fuel and heating purposes in those sections of our country, and to such an extent that it is largely taking the place of coal in the various large manufacturing establishments and in private families, at a comparatively small cost as compared with even the present cheap fuel of those sections. This natural gas is obtained in drilling to the depth of from 1,500 to 2,000 feet, and is frequently conveyed in pipes very many miles; the pressure varies, but it is extremely heavy. I merely advert to this matter to give you scientists and thinkers a little food for reflection. Is there any probability of our finding natural gas and reaching it at any practicable working depth in this northwestern country? I am impressed with the belief that our good Creator has something in reserve for us, and that this great and good country will not have to be dependent for ages upon distant localities for this all important element to the comfort of mankind. Whilst it may be scientifically thought that Minnesota is located outside the belt where natural gas can be reached, I am still deeply impressed with the belief that efforts should be made whereby the question can be practically tested, and at least use the means to the end hoped for. Very respectfully,

 SPRINGER HARBAUGH.

VII.

THE DEEP WELL AT LAKEWOOD CEMETERY, MINNEAPOLIS.

This well is situated on the south side of the cemetery, near the beginning of the tamarack swamp, which connects lakes Calhoun and Harriet, but on high ground, about 50 feet above the lake. It is 75 feet above the Milwaukee depot, or about 900 feet above the sea.

The following general statement of the drift was obtained from the Superintendent (F. M. Gray) and from observations on the drillings as they were shown during the progress of the work. Samples of these, and of the rock strata, to the bottom of the well have been preserved and are deposited in the General Museum for future reference and verification:

1. Gravel and sand; mainly referable to the blue till as its source. It is suitable for road-making; the upper portion of this, not noticed by Mr. Gray, consists of yellow loam, such as covers the most of the country, making the soil, having a thickness of 1-4 feet..... 135 feet.

2. Yellowish, ochery, or rusted clay in which the stones, and all boulders, one of which was broken and brought up in fragments, have a ferruginous coating or weathering..... 135–138 feet

[This seems to have been the bottom of the old preglacial (rather interglacial) river gorge. It is evinced by this weathered material. A boulder of syenitic gneiss as large as a man's fist, which was said to have been brought up in the pump, was exhibited by the men at work. It was weathered and looked so much like a surface pebble, such as can be found anywhere now on the top of the ground, that at first this statement was disbelieved. But when the Superintendent showed a piece of hard gray granite, evidently freshly fractured by the drill, having a red weathered exterior, I was inclined to believe that the pebble of gneiss also may have come from this depth.]

3. Blue till..... 138–212 feet.

4. Gravel and sand and blue till. This was changeable, and seemed to be as if interstratified, but of course that could not be stated on the basis simply of the pumpings..... 212–248 feet.

5. Boulders of Trenton limestone, and of granite, with some sand all more or less involved with some blue till. The rock was struck next below this, and at a depth of 264 feet beneath the surface. This depth seems to demonstrate the existence of some great excavation in the strata, probably, as supposed in the report on Hennepin County,* the old gorge of the Mississippi river, at least in interglacial times..... 248–256 feet.

6. Quartzose sandstone, in friable strata or massive, composed of rounded grains of pure quartz..... 256–276 feet.

7. The same..... 276–296 feet.

8. The same..... 296–318 feet.

9. At the depth of 318 feet about one-half of the washed drillings are found to consist of dolomitic rock, and the rest of the same white sand. Some of the coarser fragments show that this dolomite is compact, fine grained, of a yellowish-gray color, approaching, in both respects, some of the strata of the Cambrian. Occasional fragments of crystalline rock, found in the drillings here, and before, evidently are derived from the drift below the point at which the pipe stands on the boulders, etc., of No. 5..... 318–320 feet.

10. At 325 feet the pumpings consist almost entirely again of white sand. Hence the dolomitic layers seem to have been not greater than ten feet in thickness..... 320–325 feet.

[At this point some pebble or other obstruction in the drill-hole caught the drill and caused the breaking of one of the wooden poles, and a delay, the drill being lodged and wedged fast. When the drill was got started again and the pumpings were preserved, the samples exhibited (Aug. 15) were said to have come from the depth of 360–403 feet, and nothing was said of the interval between the last preserved record (325 feet) and 360 feet. Hence there is no certainty whether it contained drillings like those at 325 feet or at 360 feet.]

11. Slightly red, fine grained, dolomitic rock, of homogeneous characters..... 360–403 feet.

12. About one-half of the drillings are like the last, and the rest are of rounded, white, translucent, quartz-grains like the next. It is probable that the mixture is occasioned by the infrequency of the pumping, and not by an original mixture in the rock. The transition from dolomite to sandrock took place in this interval..... 403–416 feet.

13. Translucent, rounded grains of quartz, almost nothing else..... 416–424 feet.

14. The same as the last. At the time of this visit the workmen exhibited some fragments consisting of white chert coated

* Fifth Annual Report, page 177.

with fine rhombohedrons of dolomite of the same reddish color as the rock at No. 11, with a few scattered cubes of pyrite, but they could not assign any definite horizon to them, saying they picked them out of the pumpings. They are probably from the reddish dolomite, but may be from the top of the sandrock when the passage from one to the other is apt to alternate from sandrock to dolomite in thin beds accompanied by chert..... 424 – 434 feet.

14. White quartz sand, rounded..... 434 – 481 feet.

15. White quartz sand, with traces of light green shale, and occasional small, aggregated, clustered, cubes of pyrite, the clusters being about the size of mustard seeds ..... 481 – 504 feet.

16. White quartz sand, rounded, with some green shale. In mass this does not appear so clearly white as the last two, but a dirty white, apparently due to some soft, colored material ground up by the drill, which, on getting dry cements the sand grains into fragile lumps..... 504 – 558 feet.

17. White sand and green sand, the latter mainly ground to a fine powder, so as to stain the whole and make a greenish, fragile, loose mass, when dry. Some of the green sand is like the distinct green sand lumps seen in the St. Croix, at Red Wing..... 558 – 607 feet.

[The interval unrepresented by drillings, from 607 feet to 694 feet, probably was made up of the same as the last, or, perhaps, more like the next.]

18. White sand..... 694 – 763 feet.

19. Mainly white sand, but having a mixture of other grains that are not silica, and of a heavy cementing substance that, when dry, seems to be a powdered rock of some sort, of a light buff and pinkish color. The mass, however, does not effervesce. Some scattered grains are green and soft, and may be the source of the coloring cement..... 763 – 780 feet.

20. Green clay or shale; non-effervescing, very fine grained.. 780 – 935 feet.

21. White sand, with a faint yellowish tint..... 935 – 1005 feet.

22. Siliceous sand, with a faint pinkish tint, rather fine.....1005 – 1010 feet.

23. Siliceous sand, with a deeper pinkish tint, rather coarse grain, some of the grains being amethystine, and others of a light yellow color..... .1010 – 1060 feet.

24. Siliceous sand like the last, but of a lighter color .....1060 – 1105 feet.

25. The same, but cemented, when dry, with ground-up, reddish shale, probably derived from some beds introductory to the next.....1105 – 1123 feet.

26. Compact, red clay, or shale, like that seen at Fond du Lac, below the red sand rock, and interstratified with it.... ....1123 – 1167 feet.

[At some places between 1123 and 1167 feet, several pieces of red shale, mottled with light green, were brought up by the pump. Some of these are two inches across. They are fine-grained, gritless, and sparkle with fine flakes of talc or mica. The green portions of this shale are finer grained than the red, and also are harder. The red has a powder that is reddish-umber in

color, and the green parts have a powder nearly white, or at least greenish-white. Within the green can be seen, under the loop, scattered, distinct grains, of much darker green, nearly black, which are about as hard as talc, and mash easily under pressure, with a greenish powder. The greenish shale seems to be subcrystalline. It occupies patches that are broad but thin, and constitutes but a small part of the whole; but it is intimately blended with the red in structure. According to Mr. Gray, this reddish-brown shale gradually became harder, and at 1235 feet it was a hard rock, and continued so to at least the depth of 1286 feet, where the drill was at work when this information was obtained.

At 1235 feet a somewhat harder stratum was reached. The drillings have a reddish color, but show angular fragments of gray or greenish slaty rock, soft, gritless, glittering with fine flecks and resembling Nos. 450 and 452 of the geological survey series (blue), but less hard. These fragments evidently show the nature of the rock at this depth, the red color of the drillings being caused by intermingling with material from the overlying beds, the well at this depth not being piped. Some of the fragments of gray or light green shale are an inch across. The sand grains, and all the reddish coloration, are undoubtedly from the higher strata. The gray-green shale is fragmental, not crystalline, except as it may contain grains from the crystalline rocks, glitters with light-colored scales of mica, macerated by water and friction, and also holds rounded grains of a green substance, which outwardly is nearly black but within is much lighter, and which mashes easily, evidently the same substance as mentioned already.]

27. Reddish-brown schist, hardness about four and one-half or five, with a gray streak or powder, glistening with reflecting, minute points of some mineral which it is impossible to name, but which may be mica scales. This has the general outward aspect of an impure hematite, but its powder and its weight show it is not an iron ore of any kind. On washing a considerable quantity of the drillings from this interval (really labeled from 1260–1380 feet), the residue consists of grains of a great variety of rocks, demonstrating that great care must be taken in drawing inferences from the appearances of the drillings furnished by the usual well driller, and that the drillings from the upper portions of the well are constantly mixed with those derived from below, in such abundance often as to screen entirely the true character of the lowest strata from the notice of the geologist. The grains in this instance consist of the following kinds: (1) Conspicuously, white, limpid sand. (2) Brown schist, with a gray or light streak, making the greater part. (3) Soft greenish slate. (4) Red, soft shale with spots of green. (5) A few bits of an arkose-like sandstone, with a pea-green interior color. (6) A gray, hard, fine-grained schist, not foliated like (2), but having an angular

fracture, as if massive, and (7), A single, large piece, of a dark, medium-grained, massive rock, like a dioryte. These last, (6 and 7), evidently are from near the bottom of the drill, as they are the last to appear among the drillings.....1167-1400 feet.

SUMMARY OF THE WELL DRILLED AT THE LAKEWOOD CEMETERY.

1. Drift, 1-256 feet..... 256 feet.
2. White sandrock, 256-318 feet..... 62 feet.
3. Dolomitic rock, 318-403 feet..... 85 feet.
4. White quartz sandrock, 403-504 feet..... 101 feet.
5. White quartz sand and green sand, 504-780 ft. 276 feet.
6. Green clay or shale, 780-935 feet..... 145 feet.
7. Siliceous sand, yellowish or pinkish, 935-1105 feet..... 170 feet.
8. Soft red shale and sandstone, with greenish mottlings, has red powder, 1105-1167 feet... 62 feet.
9. Harder, reddish-brown rock, not arenaceous, a schist, has light gray powder, 1167-1400 feet..... 233 feet.

The boring ceased at 1400 feet.

The drilling of this well was subsequently continued to the depth of —— feet. At 1860 feet the washed drillings consisted largely of white, limpid, rounded quartz grains, from above, and of a gray, tough crypto-crystalline rock, which showed the nature of the rock at that depth, resembling many of the strata seen in the rocks at Thomson and thence to Knife Falls, of which the survey numbers four hundred and sixty-nine and four hundred and seventy-three might be mentioned. Some larger fragments were black and graphitic, and throughout the whole were numerous battered films of metallic iron from the drill.

VIII.

NOTES ON THE ARTESIAN WELLS AT MENDOTA, HASTINGS, RED WING, LAKE CITY AND BROWNSVILLE, AND ON THE DEEP WELLS AT ST. PAUL.

The well at Mendota was drilled by W. E. Swan, and the following designations are his. The point at which the well begins is sixty-five feet above the Mississippi river, within the river gorge, and so near the rock bluff composed of the Trenton limestone and the St. Peter sandstone that the drill encountered some of the old, fallen masses of the limestone at some depths below the top of the St. Peter, which is visible in the immediate bluff about fifty feet distant. The St. Peter sandstone rises forty-seven feet above the top of this well. The top of the well is about seven hundred and fifty feet above the sea.

No. 1.	Limestone. [Fallen masses of the Trenton—N. H. W.]...	22 feet.
No. 2.	Brown sandrock.....	60 feet.
No. 3.	Blue shale.....	30 feet.

[This, which here is designated blue shale, is probably not all blue shale. It holds the place of the Shakopee limestone, and is about on the horizon where the known upper strata of that formation, about a mile east of Hamilton, with the theoretical dip that must be assumed toward the northeast, would require the Shakopee. The Shakopee everywhere in Scott and Dakota counties causes remarkable bogs, indicating the impervious, shaly nature of the formation. Moreover, it becomes arenaceous, as well as shaly, as may be seen at Northfield. Its firmness, under erosion, is reduced by these qualities, and it also is less frequently seen—N. H. W.]*

*According to Rev. James Dobbin, the following alternations of strata were found in sinking a well at the Shattuck School, Faribault, indicating that the top of the Shakopee there was found to be a blue clay 5 feet thick: Clay soil, 9 feet; limerock, 21 feet; sandrock, 117 feet; stiff, blue clay, 5 feet; fine, brown sand, 3 feet; striking a very hard stone, which was regarded granite, but which was probably the firmer dolomitic beds of the Shakopee, which can be seen in the valley of the Cannon river, a few miles further north, and near the Cannon Valley roller mill.

No. 4.	Sandrock	35 feet.
" 5.	Magnesian limestone	145 "
" 6.	Sandrock	95 "
" 7.	Gray shale	50 "
" 8.	Green shale	110 "
" 9.	Limestone	10 "
" 10.	Blue shale	30 "
" 11.	Sandrock	50 "
" 12.	Gray shale	40 "
" 13.	Green shale	35 "
" 14.	Very hard red sand rock, enclosing beds of red shale	145 "
	Total	857 feet.

"No. 5 of this well seems to be the same limestone that outcrops at Hastings. We struck a crevice when we got 40 feet into this stratum, from which the water began to flow at the rate of 40 gallons per minute. A second flow of water was obtained from No. 11 (sandrock). When we got through that sandrock, the well flowed 300 gallons per minute. After we got through drilling we tubed the well and separated the upper vein of water from the lower vein, and we found the lower water to be much softer than that which comes from the upper vein. We also found that the water from the lower vein rose 14 feet above the surface, while that from the upper vein would only rise 4 feet. No water was obtained from the red sandrock (No. 14); there was no increase in the flow after passing through No. 11."

The Hastings deep well was drilled by W. E. Swan, and the information here given respecting the character of the strata is derived from his notes and from a series of the preserved drillings which he has furnished. This well is located at the depot of the Chicago, Milwaukee and St. Paul railway, about seven hundred and ten feet above the sea, and about ninety feet below the top of the St. Lawrence limestone as exhibited in the bluffs adjoining. The water rises fourteen feet above the surface.

1.	Dolomitic limerock. *St. Lawrence*	80 feet.
2.	Sandrock	15 "
3.	Dolomitic grit, (Mr. Swan designated this limestone)	12 "
4.	Sandrock, supplying no water	95 "
	[Some of this is coarse and some is fine. In the lowest ten feet the drillings contained fragments and rusty tubes that recall the tubes in the St. Peter sandstone described in Vol. 1, p. 656, but these are much firmer.]	
5.	Sandy shale, white, mostly sand	25 "
6.	Gray shale, with much sand and some dolomite	43 "
7.	Green shale, *i. e.* sand and green sand	20 "
8.	Green shale, probably pulverized green sand	110 "

9.	Sandy shale, sand and green sand	15 feet.

[Nos. 6, 7, 8 and 9 may all be described as sand and green sand.]

10.	Sandrock with a few lumps of iron pyrite	20 "
11.	Sandrock with a few lumps of iron pyrite	20 "
12.	Sandrock with more iron pyrite; first flow of water	20 "
13.	Gray, sandy shale	20 "
14.	Blue shale	70 "
15.	Sand and pulverized green sand	20 "
16.	Dolomitic grit with gray shale and sand	5 "
17.	Sand rock with lumps of iron pyrite and dolomitic grit Second flow of water	5 "
18.	Sandrock with some pyrite	25 "
19.	Sandrock, coarse	10 "
20.	Sandrock	10 "
21.	Sandrock, coarse	10 "
22.	Sandrock	100 "
23.	Sandrock, coarse	30 "
24.	Sandrock, fine and coarse, some grains one-quarter inch in diameter, one of black quartzite, with traces of red shale	40 "
25.	White quartz sand, mixed with pinkish, apparently orthoclose sand, and some grains of red and black quartzite	30 "
26.	Red shale, with some white quartz sand	20 "
27.	Red and white sand with pieces of battered metallic iron, doubtless from the drill	15 "
28.	Red shale	40 "
29.	Mainly white quartz sand, but tinted red by bits of shale and other red grains; contains bits of metallic iron	75 "
30.	The same but more red	50 "
31.	The same; the shale is soft and has a red powder, like hematite	110 "
	Total depth	1160 feet

This well flows about one hundred gallons per minute and raises the water fourteen feet above the surface. There seems to be a very small portion of salt in the water. We all expected to get a large flow at Hastings, and were greatly disappointed at the result.

The Red Wing well is at and on the same level as the depot of the Chicago, Milwaukee & St. Paul railway and hence six hundred and eighty-seven feet above the sea. It was drilled by Mr. W. E. Swan, and the information below is derived entirely from him. It begins and ends in the St. Croix formation.

No. 1.	Sand and gravel	40 feet.
" 2.	Sandy shale	10 "
" 3.	Blue shale	50 "
" 4.	Sandrock	10 "
" 5.	Blue shale	30 "
" 6.	A mixture of sand, quartz and limerock	45 "
" 7.	Soft sandrock	265 "
	Total	450 feet.

"This well flows eight hundred gallons a minute at the surface, above which its water rises, when confined in a pipe, to the height of seventy-five feet. It is the largest flow for the depth that I have seen in my experience of twenty-one years. It began to flow over at one hundred and ninety feet from the surface and kept on increasing to the end. We stopped drilling in [at] the red sandrock. I have no faith in getting an increase of water after we strike it, as it always gets very hard, so that we cannot drill more than sixteen feet in twenty-four hours, while in the sandrock where we get our flow, we have sometimes drilled from five to fifteen feet an hour." *

The Well at Lake City was also drilled by Mr. W. E. Swan. He has supplied the survey with a series of the drillings in bottles. His designations were published in the Museum report for 1881, [tenth annual report, p. 161], and are here repeated with such corrections as a study of the drillings requires. This well passes through a considerable thickness of drift, showing the great depth of the Mississippi gorge at that place, being at least two hundred and ten feet below the top of the well. The depot at Lake City is seven hundred and five feet above the sea. and this well is on the same level, and forty-one feet above the low water level of lake Pepin. The well begins in the St. Croix formation.

1.	Black soil	2 feet.
2.	Yellow clay	40 "
3.	Gravel and sand	160 "
4.	Fine loam-clay	5 "
5.	Sand, this seems to be the beginning of the rock	18 "
6.	Coarse sand	7 "
7.	Sand	208 "
8.	Sand, rusty or stained with light red shale	5 "
9.	Sand, very coarse, white grains often fractured	15 "
10.	Sand, stained with red shale, and with flesh red grains	35 "
11.	Sand	5 "
12.	Red shale and sand; shale is soft and has a red powder	230 "
	Total depth	820 feet.

* Col. Wm. Colvill says that at Christ's Brewery, Red Wing, is a deep well that spouts three hundred barrels per day, rising thirty feet above the surface—one hundred and sixty feet in drift and one hundred feet in sandrock—eighty rods west of the Milwaukee depot and three rods south of the track and thirty feet above it.

The artesian well at Brownsville, in Houston county, was an experiment for increasing the supply of water to the grist mill of Messrs. Shaller Brothers. According to Mr. Swan, who drilled the well, the discharge is 1,000 gallons per minute, soft water, and granite was reached at 590 feet, where the work ceased. The mouth of this well may be 25 feet above the Mississippi river, or 650 feet above the sea, and the water rises 12 or 14 feet above the surface of the ground. The Potsdam seems here to have been wanting, and the St. Croix deposited unconformably upon the granite.

No. 1.	Blue clay	40 feet.
No. 2.	Limestone. [Doubtful, probably a dolomitic grit—N. H. W.]	25 feet.
No. 3.	Blue shale	60 feet.
No. 4	Green shale	70 feet.
No. 5.	Sandrock	395 feet.
	Total	590 feet.

The first well drilled at the St. Paul Harvester Works, in 1882, was in the rattling, or chipping, room of the foundry, at a height of about fifteen feet above Phalen creek near by, or about 863 feet above the sea.* This well was drilled by N. W. Cary, to the depth of 582 feet (claimed by Mr. Cary to be 602 feet), when his work ceased. In the winter of 1882-3 it was continued, by a diamond drill, under the management of Joseph Susor, to the depth of 626½ feet. The only samples preserved from this well, so far as known, were from the part drilled by Mr. Susor. They are from 10, 20, 30, and 44 feet below 582 feet. These are pulverized, darkish gray, shaly, siliceous, probably dolomitic, agreeing with the core obtained from the second well at a corresponding depth. Owing to the supposed bed of iron and iron ore (reported to be very hard to drill), in the first well *a second one was drilled*, at a point about fifteen rods north from the first, on land about eight feet higher, or approximately 871 feet above the sea. Mr. Cary drilled in this well, during the summer and autumn of 1882, to the depth of 515½ feet. Mr. Susor, with a diamond drill, penetrated 156 feet further, or to a total depth of 671½ feet. A very complete set of the samples from this well

*The railroad at the Union Depot, St. Paul, is 701.5; water in Phalen creek, at the highest crossing of the St. Paul, Stillwater and Taylors Falls Railroad, 845; water in this creek at the Harvester Works, 848; Phalen lake, 854. Concerning the alleged discovery of a deposit of metallic iron and magnetic iron ore in this well, beginning at the depth of 560 feet, and reaching below at least 42 feet, see the *Pioneer Press* for August 24, 1882.

were courteously supplied by Mr. Kirk, from the drillings preserved in the office of the Harvester Works at St. Paul. Mr. Cary drilled a hole six inches in diameter; the core obtained by the diamond drill is about an inch in diameter. The water stands constantly in each well at 35 or 40 feet below the surface. The following descriptions of these drillings are essentially as prepared by Mr. Upham. Rock was reached at 235 feet.

No.	1.	Dark, sandy and clayey loam	1–10 feet.
"	2.	Gray sand and fine gravel containing pebbles up to three-quarters of an inch in diameter	10–20 "
"	3.	Same, with pebbles up to one and a half inches in diameter	20–30 "
"	4.	Yellowish coarse sand	30–40 "
"	5.	Yellowish sand and gravel, with pebbles up to one-half inch	40–50 "
"	6.	Yellowish sand and fine gravel	50–60 "
"	7.	Light gray sand and fine gravel	60–70 "
"	8.	Light gray sand and fine gravel	70–80 "
"	9.	Light gray sand and fine gravel	80–90 "
"	10.	Light gray, fine sand and pebbles up to one and one-half inches, slate, greenstone, etc	90–100 "
"	11.	Light gray, fine sand and pebbles up to three-quarters of an inch, including some of granite	100–110 "
"	12.	Light gray sand and gravel, with small pebbles of granite, greenstone, etc	110–120 "
"	13.	Light gray sand and gravel, with small pebbles up to one-half inch	120–130 "
"	14.	Light gray sand and fine gravel	130–140 "
"	15.	Light reddish gray sand, with rare green stone pebbles up to one and one-half inches in diameter	140–150 "
"	16.	Light reddish gray sand, with pebbles (rare) up to two inches in diameter	150–160 "
"	17.	Light reddish gray sand, with pebbles up to one and one-half inches	160–170 "
"	18.	Light gray sand, with pebbles up to one inch in diameter	170–180 "
"	19.	Coarse gravel, largely made up of pebbles (from the northeast) up to one and one-half inches	180–190 "
"	20.	Similar to last but containing more sand intermixed	190–200 "
"	21.	Same, mostly finer, but with occasional pebbles up to two inches, (one a reddish porphyry, from Lake Superior)	200–210 "
"	22.	Coarse gravel, mostly pebbles up to two inches, with little sand	210–220 "
"	23	Yellowish sand, with few gravel stones, (these probably from the stratum above)	220–230 "

" 24.	The pulverized drilling contains a large proportion of broken, angular fragments (up to one-third of an inch) of buff magnesian limestone (with some sand and gravel stones); the rock is said to have been struck at two hundred and thirty-five feet.....	230–240	"
" 25.	Light yellowish, very fine powder, slightly caked in the box, including no coarse particles or fragments; effervescing freely.....	240–250	"
" 26.	Light buff; drillings intermediate in character between the last two.....	250–260	"
" 27.	Similar to last, but more arenaceous, mainly very fine, granular (fractured), angular (also containing sand and occasional small pebbles, doubtless from above two hundred and thirty-five).....	260–270	"
" 28.	Light buff magnesian limestone, in fine (from dust up to one-twelfth of an inch) angular fragments, with grains of rounded quartz.....	270–280	"
" 29.	Magnesian limestone, yellowish buff, containing a considerable proportion of white quartz particles, some of them rounded by water, up to one-twentieth of an inch in diameter, with arenaceous chert and quartz geodes.....	280–290	"
" 30.	Mostly very fine yellowish powder (dust) nearly like No. 25, but also containing frequent angular particles up to one-quarter of an inch in diameter, of magnesian limestone..... [The samples from three hundred to three hundred and fifty were wanting and could not be found nor learned of. This part is probably limestone, which lies both above and below.]	290–300	"
" 36.	Mostly fine, light gray powder, with angular fragments up to one-eighth of an inch, of fine grained magnesian limestone that effervesce freely	350–360	"
" 37.	Sandstone; light yellowish, fine, largely (half or more) composed of white quartz grains, well rounded, up to one-thirtieth of an inch in diameter, with dolomitic powder.....	360–370	"
" 38.	Limestone; light yellowish buff, nearly like No. 36, excepting color.....	370–380	"
" 39.	Sandstone; light gray; all the grains water-rounded mostly one-sixtieth to one-twentieth of an inch in diameter, or finer; none coarser than one-twentieth of an inch.....	380–390	"
" 40.	Same as last, mostly beautifully rounded white quartz grains, with pieces of coal, metallic iron and furnace slag.....	390–400	"
" 41.	Same as last, becoming more yellowish, with a few bits of coal and flattered scales of metallic iron.....	400–410	"
" 42.	Same, with a few grains of shining black coal and scales of metallic iron, the latter largely oxydized...	410–420	"

" 43.	Same, but finer and whiter; grains not exceeding one-fortieth of an inch, all well rounded, with some pyrite, and a few iron scales	420–430	"
" 44.	Same as last; very light yellowish, with slight traces of coal and iron scales	430–440	"
" 45.	Same as the two preceding, with a few grains of pyrite with grains of rounded quartz firmly cemented to them and scales of iron	440–450	"
" 46.	Still finer water-worn sandstone, very light gray, almost white	450–460	"
" 47.	Coarse (up to one-twentieth of an inch), with much also that is very fine; yellowish gray; well water-worn, with iron scales (rusted) and grains of a black scoria; also contains traces of green shale and some dolomitic powder	460–470	"
" 48.	Very fine; very light yellowish; well rounded; much like No. 46, with coal (anthracite), one piece being three-tenths of an inch in diameter; scoria and scales of iron	470–480	"
" 49.	Very fine; light leaden gray, arenaceous (and perhaps dolomitic) shale; (caking somewhat in the box) effervesces	480–490	"
" 50.	Very fine (more so than last) light dusky gray, arenaceous shale; caking harder than the last	490–500	"
" 51.	Similar to the last but more arenaceous, with much sand of white quartz, up to one-hundredth of an inch in diameter	500–515	"

[At five hundred and fifteen feet the pulverized drillings stop, and the remainder of this well is represented by samples of the core of the diamond drill, about one inch in diameter.]

Core from Diamond Drill.

At 555 feet. "Core at 40 feet (six inches" of core).	Gray, compact and hard, fine-grained sandrock, probably dolomitic; inclosing occasional shaly, darker laminae, and having in some portions dark specks of greensand.
At 578 feet. "Jan. 1st, 1883; at 63 ft.,— 18 inches of core."	Same as the preceding.
At 590 feet. "75 feet — 12 inches of core."	Light yellowish buff, compact and hard, very fine grained sandrock, probably dolomitic; containing mica scales (?) [very minute shining facettes]; (not shaly and having less greensand.)
At 626 feet. "111 feet — 11 inches of core."	Similar to the last, but with light green streaks and irregular blotches, up to one-quarter of an inch thick, vertically, yet not more than three-quarters of an inch long, thinning at each side to one-twentieth of an inch or less in thickness; some fine shale.

At 650–660 feet.
"Jan. 8th. This is from 135 to 145 feet. JOSEPH SUTOR."
(About 5 feet of core.)

Hard and compact, alternately arenaceous and shaly, probably dolomitic; in color about one-tenth part buff; about one-half dusky gray; and about two-fifths dark green. The layers of dark greensand not so hard as the other portions, vary from one-twentieth of an inch to two or three inches in thickness, being interbedded with the dusky and buff layers

The deep well at Elevator B., St. Paul, is situated near the centre of the southwest quarter of the southeast quarter of section twenty-five, about three and one-half miles west from the Harvester Works wells, beginning about eight hundred and fifty-five feet above the level of the sea. The drillings from this well were examined by Mr. Upham, through the courtesy of Mr. W. S. Zimmerman. The entire depth is eight hundred and fifty feet, drilled by N. W. Carey. Water stood at thirty-five feet below the surface during the entire progress of the work.

1.	Dark gray, fine sand, at 40 feet.	
2.	Dark gray, fine sand	40–58 feet
3.	Light gray, shaly limestone	58–63 feet.
4.	The same	63–69 "
5.	Light yellowish gray, very fine grained, arenaceous (?) shaly	69–83 "
6.	Fine grained, white sandstone	83–235 "
7.	Light gray; somewhat argillaceous, fine grained, apparently sandstone	235–265 "
8.	Buff magnesian limestone in angular fragments	265–300 "
9.	Fine grained, white quartz sandstone, water-rounded	300–320 "
10.	Buff magnesian limestone	320–335 "
11.	Fine, light yellowish powder, no grains visible	335–375 "
12.	White sandstone, in small part iron rusted, water-rounded	375–436 "
13.	Light buff, gritty stone, like the core of the diamond drill in the Harvester Works well	436–437½ "
14.	Sand, light gray, or nearly white	437½–478 "
15.	Light gray shale	478–515 "
16.	Very fine bluish shale	515–523 "
17.	Very fine, light gray shale	523–529 "
18.	Very fine, light yellowish gray sandstone, somewhat argillaceous	529–540 "
19.	Very fine sandstone, with some dark green grains	540–560 "
20.	Very fine shale, olive green	560–589 "
21.	Nearly the same as the last, with some sand	589–604 "
22.	Light gray shale, with some sand	604–672 "
23.	Fine grained sandstone, dark gray	672–738 "
24.	Light gray shale, very fine grained	738–761 "
25.	Unknown	761–850 "

The well at the Harvester Works apparently struck the St. Lawrence, the depth to the rock indicating the absence of the Shakopee and Jordan. The well at Elevator B exhibits some irregularity. The "blue shale" which at Mendota seems to represent the Shakopee, below a thickness of a hundred and twenty-nine feet of sandstone (including forty-seven feet visible in the face of the bluff), is not mentioned at all. It may have been passed without being noted in the one hundred and fifty-two feet reported as sandrock, or it may be represented by Nos. 7 and 8. In the latter case it would coincide with the recognized dip of the Trenton between Mendota and Elevator B, which amounts to about twenty-five feet, bringing the top of the Shakopee at Mendota at about six hundred and fifty-five feet above the sea level, and at Elevator B six hundred and twenty feet. The underlying white sand (twenty feet) would be the Jordan, which in the Mendota well is reported to be thirty-five feet. This parallelism, however, requires the reduction of the St. Lawrence from one hundred and forty-five feet, reported in the Mendota well, to fifty-five feet as reported in the Elevator B well. The same stratum at Lakewood cemetery is given at eighty-five feet.

Any person who has had occasion to record and compare the reports of well-drillers, or to obtain the drillings of wells for his own examination, will appreciate the difficulties and the uncertainties of such records. The drillings are not carefully preserved; the depths from which they are obtained are not accurately stated, nor even known, and the changes in the rock from stratum to stratum cannot be located with precision. Some broad stratigraphic distinctions can generally be made out.

In the case of the wells foregoing it seems necessary to state that the Shakopee formation dwindles toward the north and northeast in this latitude, as already well known further south. The sandy and clay constituents increase at the expense of the calcareous. This is true also of the St. Lawrence, which at Hastings, and apparently at Stillwater, embraces one or more strata of white sand from ten to twenty feet in thickness. These are comparable to these thinner beds of white sand that are intercalated in the Shakopee, seen at Northfield.

IX.

FOSSILS FROM THE RED QUARTZYTE AT PIPESTONE.

About the middle of October, on the occasion of a visit to Pipestone to obtain specimens for the World's Cotton and Centennial Exposition at New Orleans, in a cursory examination of a lot of the pipestone material in the possession of Mr. C. H. Bennett, certain markings were noticed that had the aspect of small fossil shells, and on some further search several slabs were found which had great numbers of the same impressions thickly scattered over the surface of the bedding side. Subsequently other slabs were found at the Indian quarry which had the same marks freshly exposed by recent operations at the quarry.

These fossils occur in the blood-red catlinite, which is the only kind used by the Indians, though it is possible that they can be found also in the light-colored slabs. They consist of thin lenses about six millimetres in diameter, imbedded in the otherwise homogeneous pipestone. They might be taken for inorganic flattened concretions were it not that they exhibit indistinctly some evidences of organic structure, and when they are removed, along with more or less of the pipestone material, the portion removed, embracing the powdered white scales, shows, on chemical analysis, the presence of phosphate of lime.

Subsequently Mr. A. W. Barber, of Yankton, Dakota, found a trilobitic form among the debris of the old Indian quarry, and it is described below, with his name, as a specific designation.

LINGULA CALUMET.

The shell, so far as can be determined by the fossil remains, was very thin and fragile, containing some phosphate of lime, and nearly circular, averaging somewhat less than a quarter of

an inch across. When freshly uncovered it is of a light flesh color, and resembles the light colored spots that have often been mentioned in the blood-red catlinite, but is much lighter. That these light spots, however, are distinct from those, and different, is evident at a glance. Those light spots have no constant form nor size within the rock. They vary from the size of pin-points to areas covering several inches. They are not so related to the structure that they are uncovered by splitting the rock along its bedding planes, but are as likely to be exposed by a fracture across the bedding. They do not wear away readily by friction, but enter the mass of the rock, while these are so thin that a short exposure to the weather destroys them, leaving only the outline of the shell, either the interior or exterior, outlined in the blood-red catlinite. A section across them is all of the same color; that across these shows a thin scale of the light colored matter embracing a small lenticular mass of the same aspect as the main mass of the rock, of a blood-red color. Those are disseminated porphyritically through the mass of the rock; these lie only in thin sheets (apparently only in one plane) coincident with the bedding, their flatness being in that direction in which a thin bivalve would necessarily lie on the bottom when acted on by sedimentation.

These lenticular bodies, when both valves are preserved in apposition, are about one-half millimeter in thickness; and when only one valve is present there is only the form of the shell preserved, with the merest trace of a scale, that probably represents the shell itself.

There is in some instances a very indistinct, rude, lamellose, concentric marking on the exterior. On the interior of the valves, *i. e.*, on the concave impressions, there is quite frequently a distinct, marginal, flat band, which is separated from the central part by a faint ridge. This ridge may have marked the limit of the general visceral cavity.* The beak of the longer valve is rarely seen in its prolongation beyond the other valve; but there is very often an impression that shows a decided elongation of the shell, such that it could not be described as circular. The smaller valve approaches nearer the circular form. The following figures show some of these features, magnified two diameters. Most of those indistinct markings are similar to

* The appearance of this marginal ridge, in its undulating course, is very similar to that represented in *Obolus Apollinis*, by fig. 282, pl. ix, of Davidson's Introduction to British Fossil Brachiopoda, vol. 1.

those of *Lingula inchoans*, Barr., illustrated by figures 74 and 75 of Barrande's *Faune silurienne des environs de Hof*, en Baviere. This shell, however, is about double the size of that.

EXPLANATION OF FIG. 6. — PLATE I.

Fig. a. Impression of the beak of the longer valve (concave).
Fig. b. Impression of the shorter valve (concave).
Fig. c. Convex surface of a small specimen.
Fig. d. Concave impression of the longer (?) valve.

Locality and position. In the catlinite at the great pipestone quarry, in Pipestone County. Museum register number, 5559. Collector, N. H. Winchell.

PARADOXIDES BARBERI. (N. SP.)

The specimen found by Mr. Barber has been crushed and folded upon itself by some pressure obliquely applied from the right and somewhat from the rear, so that the pleuræ of the left side are turned underneath the animal, but exhibit their furrows and ridges alternately to the number of fourteen or fifteen furrows, separated by as many ridges. The segments of the axis are thus thrust forward over the crumpled pleuræ of the left side, showing more or less of the articular portion of several of the segments. The specimen shows but slight traces of the original crust of the animal. At several places, however, and particularly in the sheltered joints along the axal furrows, small fragments of a thin, red, shining covering remain. The specimen has long been weathered. It is much roughened by the exposure, and injured as a fossil by this fact. It has been in contact with the camp fires of the Indians, as evinced by the blackened condition of the under surface.

The cephalic shield, including the glabella, is wanting; but there are two or three furrows that can be seen to cross the anterior portion of the specimen, as if due to the original furrows of the glabella, and another terminates before reaching the middle. Whether this termination of one of these furrows be due to the pushing together and overlapping of the segments under oblique pressure, or to an actual and natural character of the shield, cannot be ascertained. The whole left side, and much of the central lobe, throughout the thoracic portion, are obscured by the same accident. The accompanying figure (7) of plate I. ex-

presses the character of this fossil better than any description that can be written of its visible characters. About fourteen ridges can be counted on the under side, expressing the number of the pleuræ folded beneath. But in advance of these fourteen are about two more on the upper surface, some of them exhibiting a tendency to duplication, caused by the pleural grooves. The thoracic segments may be considered to have reached sixteen, at least. On the right side from twelve to fourteen segments can be counted, although there are several that are narrow and seem to be due to the crushing down of the right side by an oblique pressure on the pleural grooves.

It is possible that this specimen belongs to some described species, but it would plainly be premature to assign it to any known species at present. It is thought best to give it the name of Mr. A. W. Barber, who discovered it, and await the finding of better material to correct any error. The figure is drawn of the natural size.

Position and locality. The catlinite layers at Pipestone; collected by A. W. Barber. Museum register number, 5555.

The following letter was received from Mr. S. W. Ford, who for some years has been at work on a similar fauna found in eastern New York, and is familiar with obscure forms of organic remains under such circumstances.

S. W. Ford on the pipestone fossils.

SCHODACK LANDING, RENSSELAER COUNTY, N. Y.,
February 14th, 1885.

Prof. N. H. Winchell,

MY DEAR SIR: I have examined with deep interest, and on several different occasions, the supposed fossils from your "red pipestone" rocks of Minnesota, which you kindly submitted to me for study, and have no hesitation in pronouncing them organic. I have endeavored to study the specimens without bias or prejudice; indeed I think I can safely say that my mind has been uninfluenced by any prepossessions concerning the age of the terrane affording them, although aware from the perusal of your writings, as well as those of others, that the disposition has been rather strong of late years, to rank the quartzite as "Huronian."

Your principal specimen (No. 5555) I believe to be a trilobite and most probably a *Paradoxides*, although it may possibly represent the somewhat newer primordial genus *Olenellus*. The specimen has been distorted by pressure exerted obliquely across it from behind, forcing the extremities of the left hand posterior pleuræ underneath and diagonally across the body-axis, and

carrying the axis itself a little to the left. The cephalic shield is wanting. There appear to be from twelve to fourteen body-rings represented, and there are indications that the higher of these figures would be below the actual number in the individual if complete. Along the forward lef hand portion of the specimen, there are patches of what I believe to be the altered test of the creature still remaining. The thickness of these films agrees well with the known thickness of the test in trilobites of the genera *Paradoxides* and *Olenellus*. I may add that I also noticed in my study of the body-rings evidences of the usual "articular folds" of trilobites.

The other specimens appear to me to be most probably *Lingulæ*, and the examples to which I have attached tags, or pointers, seem decisive upon this point.* But what the species may be I have no idea. The specimens are all in the condition of casts, and although at first disposed to think that the peculiar pitting noticed in the rostral portion of some of the examples, pointed to *Siphonotreta*, I have since been able to satisfy myself that they are only the casts of sand grains in the pipestone. I have in my collection from the "Acadian" of New Brunswick, slabs crowdedly covered with *Lingulæ* of small size which strikingly suggest a like age for your specimens, and while I cannot feel sure of my position, owing to the imperfection of the materials studied, I am, nevertheless, strongly impressed with the belief that your red "pipestone" fossils are most probably "Acadian."

It affords me much pleasure to add that the results of my examination of your specimens sustain, for the most part, the views you were disposed to take of their generic relations, as expressed in your letter of the sixth instant, accompanying them.

Thanking you for your courtesy and kindness,

I remain, dear Professor,

Very truly yours,

S. W. FORD.

The following is an extract from a letter from Prof. J. D. Dana, respecting these fossils:

NEW HAVEN, CT., February 25, 1885.

Prof. N. H. Winchell,

DEAR SIR: I am much pleased to have had the privilege of seeing your catlinite fossils. There appears to be no mistake about them, and the little, nearly circular shell, is, as you say, closely like *Lingula*, as far as its characters are discernible. The trilobite might be considered a doubtful fossil, or doubtful whether or not a fossil, were it not associated with other species. But as the case stands there is no good reason for doubting it, and it is an exceedingly interesting find. I believe in fixing the age of even crystalline rocks by fossils, and that has been my heresy; and I am glad that you are having success in that direction. There are some Archæan rocks that have Archæan stamped on them — those that contain chondroditic limestones, and abound in hornblende, scapolites and zircons. But many of them are of ambiguous character, and need to have somewhere an overlying bed of unmistakable primordial (Cambrian) to make their Archæan age certain. . . .

Yours truly,

JAMES D. DANA.

* One of these is b of figure 6, plate I.—N. H. W.

It is well known, from the researches of Wm. E. Logan and T. Sterry Hunt, that the composition of the shells of recent and fossil Linguläe is made up to a considerable extent of phosphate of lime.* For the purpose of comparison a specimen was handed to Prof. Dodge, who has made the following report:

Prof. James A. Dodge, on the composition of the shells of the fossil Linguläe from Pipestone.

THE UNIVERSITY OF MINNESOTA,
CHEMICAL LABORATORY.

MINNEAPOLIS, MINN., Feb. 11, 1885.

Prof. N. H. Winchell,

DEAR SIR: I have made an analysis of the white shell-like substance found on the surface of a specimen of pipestone (Chem. series No. 173), as requested by you a few days ago. I find it to consist *esentially of carbonate of lime* but with distinct *traces of phosphate of lime.*

Very respectfully yours,

JAMES A. DODGE.

The discovery of primordial fossils in the pipestone of Minnesota makes an important datum for calculating the stratigraphy of other rocks of the Northwest. This "pipestone" is a part of the great series of quartzytes which by C. A. White was styled *Sioux Quartzyte* in his final report on the geology of Iowa, in 1870. These quartzytes are conspicuous at several other places in Minnesota, and also in Wisconsin, where they have been denominated *Baraboo quartzyte* and placed in the "Huronian." Prof. James Hall, in 1867, and Mr. J. H. Kloos, in 1871, classed the quartzytes of southwestern Minnesota in the "Huronian." These fossils place them within the "primordial zone" of Barrande, a geological stage which has not yet, confessedly, been covered by the term "Huronian" at any point in America. The Paradoxides horizon, which seems to be here indicated, has been distinguished by the name *St. John's group*, or *Acadian*, and embraces the slates at Braintree, Mass. It is supposed to lie below the *Georgia slates* of Vermont, containing Olenellus, and those to be below the "red sandrock," which is the proper *Potsdam* horizon of the east. The Potsdam horizon of the Wisconsin geologists lies still higher in the primordial, and is allied, in its paleontology, to the Calciferous sandrock. It has but recently been known to exist in eastern New York. Mr.

*American Journal of Science. (2) xvii, 237.

porphyries of the *Cupriferous series* of the north shore of lake C. D. Walcott has named a number of fossils from it in the Twenty-third Regents' Report on the New York State Cabinet, collected near Saratoga.* These are from a dolomitic limestone which he considers the *Calciferous*, and, indeed, probably is the same that has been so known. Thus it becomes necessary either to abandon the Calciferous in the East as a paleontological division, extending the *Potsdam* horizon upward so as to cover it, or to abandon the claim that the Potsdam, so called by the Wisconsin geologists, as exposed along the Mississippi river, is the true Potsdam. This dilemma was pointed out in 1872, by the writer, in the first report of the survey, and again enforced in the tenth, after this discovery of Mr. Walcott had been made known.

Further, the extension of the primordial zone so much further downward in the Northwest, on the evidence of discovered primordial fossils in the red quartzyte, allows ample room for the existence of the true *Potsdam* of New York as well as of the *Georgia slate* group, between the *St. Croix* sandstone and the pipestone beds. In several deep wells that have been drilled in central and southeastern Minnesota there has been found, beneath the St. Croix sandstone, without exception, a great thickness of red and green shales, associated with some red sandstone. This sometimes has reached the thickness of nearly four hundred feet, and is succeeded below by a hard, red quartzyte or brownish red rock, fine grained or granular, which has been uniformly supposed to be the equivalent of the red quartzytes that outcrop at New Ulm and in Pipestone county. These red shales perhaps represent the *Georgia slates;* and the red sandstone connected with them, apparently expanding toward lake Superior so as to become the red sandstones there called *Potsdam* by the Wisconsin geologists (and perhaps also the Cupriferous series) may be parallelized with the true Potsdam of New York.

Intimately connected with these red quartzytes in Wisconsin are red gneisses† and felsytes, or felsitic porphyries, the quartzytes being below these rocks, and all presenting evidences of sedimentary origin (*Geol. of Wis.*, vol. ii. p. 514). These are therefore brought within the primordial zone, and can be considered as being near analogues of the red felsytes and quartz-

* Science, III, 136.

† Some of the rock at New Ulm is also a red gneiss, of fine grain.

Superior, and, if of sedimentary origin, modified portions of the *Georgia slates*, the *St. John's group* being represented by the gneissic red quartzytes of Pigeon Point and Waswaugoning Bay, at the very base of the *Cupriferous series*.

X.

THE NEW ORLEANS INDUSTRIAL AND COTTON CENTENNIAL EXPOSITION.

The exhibit of the survey at the *New Orleans Industrial and Cotton Centennial Exposition* is quite extensive. It embraces the following parts:

683 specimens of Minnesota crystalline rock samples.
specimens of other Minnesota rock samples.
56 specimens of Minnesota minerals.*
304 specimens of Minnesota fossils.*
57 specimens of Minnesota mammals (stuffed).
specimens of Minnesota birds (stuffed).
28 specimens of Minnesota soils.
49 specimens of Minnesota plants.
58 specimens of Minnesota woods.
specimens of eggs of Minnesota birds.
21 specimens of Minnesota building stones.
specimens of Minnesota (Red Wing) pottery.
126 specimens of manufactured articles of catlinite.
21 miscellaneous specimens of Minnesota rocks, slates, granites, iron ores, clays, etc.
20 maps of the state, of the scale of ten miles to the inch, designed to show the physical features, geology, distribution of timber, and the main features of climate and soil.
66 meteorites from all parts of the world.
16 bound volumes representing the stated publications of the survey.

The detailed list and description of these articles will be reported to the *Minnesota state board of collective exhibits*, and will be communicated through the state commissioner, Mr. Oliver Gibbs, Jr., to the governor.

* This number expresses the register entries; the specimens were two or three times as many.

XI.

REPORT ON THE MUSEUM FOR 1884.

The following list of additions does not include zoological specimens received since the last report, the number of which is quite large. Many of these are on exhibition at New Orleans, consisting of birds and mammals.

The specimens of plants received by the survey, in response mainly to the circular issued in the year 1876, are specified in the following enumeration. An important donation has been received from the United States department of agriculture, Washington, consisting of 1,194 species of American and foreign plants.

The condition of the museum at present is chaotic, owing to the removal of a large quantity of the specimens to New Orleans. It is expected these will be returned early in June, and they will then be restored to their places in the cases.

Collections of plants in the possession of the Geological and Natural History Survey of Minnesota, April 1, 1885.

1. *U. S. Department of Agriculture*, Washington, D. C. A collection of 638 species of American and 556 species of foreign plants. Presented 1884.

1194 species.

2. *John B. Leiberg.* A collection of Minnesota plants from Blue Earth county. Presented, April, 1883.

78 species.

3. *John B. Leiberg.* A collection of western plants from Dakota and Montana. Presented, August, 1883.

114 species.

4. *Dr. W. E. Leonard.* A collection of Minnesota plants, by the late J. C. Kassube. Presented by Dr. W. E. Leonard, of Minneapolis, Minn., 1884.

440 species.

5. *C. L. Herrick.* Minnesota plants, collected on the Geological and Natural History Survey at various times.

529 species.

6. *B. Juni.* Plants of the north shore of lake Superior. Collected on the Geological and Natural History Survey. August–September, 1878.

175 species.

7. *T. S. Roberts.* Plants of the north shore of lake Superior. Collected on the Geological and Natural History Survey, July–September, 1879.

137 species.

8. *Dr. W. E. Leonard.* Minnesota plants. Collected on the Geological and Natural History Survey, 1875-6.

64 species.

9. *Prof. N. H. Winchell.* Minnesota plants. Collected at various times.

75 species.

10. *H. V. Winchell.* Minnesota plants. Collected at various times.

150 species.

11. "*Ex herbario horti Petropolitani.*" A collection of foreign plants. Presented.

155 species.

12. *Miss Macfarlane.* A collection of plants from southern Labrador. Presented.

25 species.

13. *F. W. Anderson.* A collection of plants from Montana. Presented, February, 1885.

72 species.

14. Through Mr. Warren Upham plants have been presented from the following persons:

Dr. Geo. Vasey, Washington, D. C., 7 species of Aristida and 14 of Panicum.

Prof. C. J. Gedge, Moorhead, Minn.

18 species.

Rev. J. Scott, West Emerson, Manitoba.

24 species.

Dr. J. H. Sandberg, Red Wing, Minn.

5 species.

Mr. R. J. Cratty. Six species of rare plants from Emmett county, Iowa.

In all 3283 species, including duplicates.

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1884.

Serial Number.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
5360	1881.	Geol. and Nat. Hist. Survey	Magnesian limestone (light)	1	Kasota	Shakopee	N. H. Winchell.
5361	1884.	" "	Drift limestone	5	Burnsville, sec. 25, Dak. co.	Drift	" "
5362	"	" "	Sandstone	1	Near Ft. Snelling, Dak. co.	St. Peter	" "
5363	"	" "	"North River bluestone"	2	Rondout, N. Y.		Presented by N. H. Winchell.
5364	"	" "	Red pipestone	1	Near Rice Lake, Barren co., Wis.	Potsdam	Presented N. H. Winchell. (Layer six feet thick.)
5365	"	" "	Purple pipestone	1	" "	"	Presented N. H. Winchell. (3 feet thick, underlying No. 5364.)
5366	"	" "	Quartzyte	3	" "	"	Presented by N. H. Winchell. (Overlying the pipestone—last two numbers.)
5367	"	" "	Pipestone	7	Near Luverne, Rock co.	"	Presented by J. C. Constable. At the base of "The Mound."
5393	Nov., 1883.	" "	Sequoia Winchellii, Lesq., Lesquereux' No. 115	1	Cottonwood River, S. of New Ulm	Dakota	N. H. Winchell. Compare No. 115.
5394	"	" "	Populus elegans, Lesq., Lesquereux' No. 5155 c	1	" "	"	N. H. Winchell. Compare No. 5155.
5395	"	" "	Populus cyclophylla? Heer, Lesquereux' No. 5155 K. P. G	3	" "	"	N. H. Winchell. Compare No. 5155.
5396	"	" "	Populus litigiosa, Heer, Lesquereux' No. 5155 A. A. M	3	" "	"	N. H. Winchell. Compare No. 5155.
5397	"	" "	Populus lancastriensis, Lesq., Lesquereux' No. 5155 D	1	" "	"	N. H. Winchell. Compare No. 5155.
5398	"	" "	Platanus species, Lesquereux' No. 5155 S	1	" "	"	N. H. Winchell. Compare No. 5155.
5399	"	" "	Ficus austiniana, sp. nov., Lesquereux' Nos. 380 and 5163	2	" "	"	N. H. Winchell. Compare Nos. 3808 and 5163.
5400	"	" "	Laurus plutonia, Heer., Lesquereux' No. 5157 C	1	" "	"	N. H. Winchell. Compare No. 5157.
5401	"	" "	Cinnamomum Scheuchzeri? Heer., Lesquereux' No. 5155 I	1	" "	"	N. H. Winchell. Compare No. 5155.

5402	Nov., 1883.	Geol. and Nat. Hist. Survey	"	Andromeda Parlatorii, Heer., Lesquereux' No. 5157 A	1	"	"	"	N. H. Winchell. Compare No. 5157.
5403	"	"	"	Cissus Browniana, sp. nov., Lesquereux' No. 5156	1	"	"	"	N. H. Winchell. Compare No. 5156.
5404	"	"	"	Magnolia alternans, Heer., Lesquereux' No. 5155 B	1	"	"	"	N. H. Winchell. Compare No. 5155.
5405	"	"	"	Dewalguea primordialis, sp. nov., Lesquereux' No. 5158	1	"	"	"	N. H. Winchell. Compare No. 5158.
5406	"	"	"	Protophyllum crednirioides, Lesq., Lesquereux' No. 5155 P	1	"	"	"	N. H. Winchell. Compare No. 5155.
5407	"	"	"	Sapindus Morrisoni, Lesq., Lesquereux' Nos. 3808 and 3912	2	"	"	"	N. H. Winchell. Compare Nos. 3808 and 3912.
5408	June, 1884.	"	"	Marl	Indif.	Johnson's Lake, Minneapolis	Drift		N. H. Winchell.
5409	July, 1884.	Mr. Davis		Quartzyte (pinkish white)	1	Garden Valley, Jackson co., Wis	Potsdam?		Presented by M. Davis, of Merillan.
5410	"	Presented		Calamine	1	Endy Mine, Friedensville, Lehigh co., Pa.			From J. Eyerman.
5411	"	"		Sphalerite (gray)	4	" "			" "
5412	"	"		Greenockite	1	" "			" "
5413	"	"		Azurite	1	Cornwall, Lebanon co. Pa			" "
5414	"	"		Malachite	1	Ecton Mine, Shannonville, Pa			" "
5415	"	"		Pyromorphite	1	Wheatley Mine, Phœnixville, Pa			" "
5416	"	"		Galenite	1	" "			" "
5417	"	"		Sphalerite (brown)	2	" "			" "
5418	"	"		Hydrodolomite and chromite	1	Woods' Pit, Lancaster co., Pa			" "
5419	"	"		Hydromagnesite and chromite	1	" "			" "
5420	"	"		Magnesite	1	" "			" "
5421	"	"		Hydrocuprite	1	Cornwall, Lebanon co. Pa			" "
5422	"	"		Limonite ("pipe ore")	1	Wharton Iron Mine, lower Saucon Twp., Northampton co. Pa.			" "
5423	"	"		" (geode)	1	" "			" "
5424	"	"		"	1	" "			" "
5425	"	"		Hematite	1	" "			" "
5426	"	"		" (fossiliferous)	1	Center co., Pa			" "
5427	"	"		" (specular)	1	Isle of Elba			" "
5428	"	"		Tourmaline and quartz	8	Easton, Northampton co., Pa			" "
5429	"	"		Biotite and talc	1	" "			" "
5430	"	"		Epidote and bl. hornblende	1	Frankford, Philadelphia co., Pa			" "
5431	"	"		Turgite	1	Easton, Nthmptn co., Pa.			" "

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1884.

Serial Number.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
5432	July, 1884.	Presented	Malachite	2	Arlington, N. J.		From J. Everman.
5433	"	"	Quartz (rose colored)	1	Southford, Conn.		" "
5434	"	"	Franklinite, polydelphite, rhodonite, and willemite	1	Franklin, Sussex co., New Jersey		" "
5435	"	"	Wernerite	1	Bolton, Mass.		" "
5436	"	"	Garnet (polydelphite)	1	Franklin, N. J.		" "
5437	"	"	Zircon	1	Renfrew, Ontario, Can.		" "
5438	"	"	Calcite	1	" "		" "
5439	"	"	Fluorite	1	Rosiclare, Ill.		" "
5440	"	"	Iron ore	1	Algiers, Africa		" "
5441	"	"	Amethystine quartz	1	Clayton, Raybun co., Georgia		" "
5442	"	"	Magnetite	1	Verona, N. J.		" "
5443	"	"	Hematite	1	Chester co. lead mines, Phœnixville, Pa		" "
5444	"	"	Magnetite	1	Essex co., N. J.		" "
5445	"	"	Amphibole (tremolite)	1	Pennsylvania		" "
5446	"	"	Psilomelane	1	Wharton Mine, Northampton co., Pa.		" "
5447	"	"	Franklinite and zincite	2	Franklin, Sussex co., N. J.		" "
5448	"	Geol. and Nat. Hist. Survey	Sandstone (rusty, cemented)	1	N'r Ft. Snelling, Dak. co.	St. Peter	N. H. Winchell.
5449	"	Presented	Building stone block	1	Nininger	St. Law	1 foot by 1 foot 6 inches.
5450	"	"	Oolyte	34	Stillwater		From A. D. Roe.
5451	Aug., 1884.	Geol. and Nat. Hist. Survey	Drillings from the Humboldt salt well—lacustrine clay with lime concretions	1 bottle.	Humboldt, Minn.		N. H. Winchell. (4 to 16 feet.)
5452	"	" "	The same, but darker colored	"	" " "		" " (16 to 140 feet.)
5453	"	" "	Pebbly blue till. (Saltwater at 165 feet)	"	" " "		" " (140 to 170 ft.)
5454	"	" "	Drift gravel and sand. (More salt water.)	"	" " "		" " (170 to 180 ft.)
5455	"	" "	Dolomitic limestone (buff)	"	" " "		" " (180 to 190 ft.)
5456	"	" "	Finer drillings of the same	"	" " "		" " (190 to 300 ft.)
5457	"	" "	The same, slightly pinkish	"	" " "		" " (300 to 400 ft.)

5458	"	"	"	Reddish shale or limerock. (Washed drillings of this are mainly limerock.)	"	"	"		"	"	(400 to 475 ft.)
5459	"	"	"	Reddish sand of rounded quartz grains	"	"	"		"	"	(475 to 500 ft.)
5460	"	"	"	White sand of rounded quartz grains. (Salt water flow increased)	"	"	"		"	"	(500 to 532 ft.)
5461	"	"	"	Faintly reddish quartz grains	"	"	"		"	"	(532 to 546 ft.)
5462	"	"	"	"Soapstone" shale, red and green	"	"	"		"	"	(546 to 550 ft.)
5463	"	"	"	The same, gray in general color	"	"	"		"	"	(550 to 556 ft.)
5464	"	"	"	The same, reddish brown	"	"	"		"	"	(556 to 560 ft.)
5465	"	"	"	The same, with grains of a white air-slaking mineral, which effervesces in No. 5	"	"	"		"	"	(560 to 571 ft.)
5466	"	"	"	The same, but lighter colored	"	"	"		"	"	(571 to 592 ft.)
5467	"	"	"	Greenish gray shale, the same as No. 13	"	"	"		"	"	(592 to 610 ft.)
5468	"	"	"	Greenish gray shale, containing bits of grayish quartzyte, that feebly effervesces in H. C. L.	"	"	"		"	"	(610 to 635 ft.)
5469	"	"	"	The same unwashed	"	"	"		"	"	(635 to 638 ft.)
5470	"	"	"	Greenish gray, foliated, micaceous quartz-schist, washed	"	"	"		"	"	(638 to 639 ft.)
5471	"	"	"	Quartz, feldspar, and mica, washed	"	"	"		"	"	(639 to 641 ft.)
5472	"	"	"	Quartz, feldspar, and mica, washed	"	"	"		"	"	(641 to 644 ft.)
5546	1880.	"	"	Columnaria alveolata (Gold)	1	Near St. Charles		Trenton	"	"	
5549	"	"	"	Orthis whitfeeldi (Winch)	15	Spring Valley, 1. m. e		"	"	"	
5555	1884.	"	"	Paradoxides barberi (Winch)	1	Pipestone county		Acadian	From A. W. Barber.		
5556	"	"	"	Chlorastrolites	Indif.	Isle Royal		Cuprif	Purchased.	(In two vials.)	
5557	"	"	"	Thomsonites	"	Grand Marais		"	"	(In a vial.)	
5558	"	"	"	Hematite	9	Vermilion mines		Archa	N. H. Winchell.		
5559	Nov., 1884.	"	"	Slabs of catlinite, showing forms like small Lingulæ	Ind.	Pipestone quarry		Potsdam	"	"	
5560	1883.	"	"	Clay pebbles	"	Princeton		Drift	U. I. Small.		
5561	1883.	N. H. Winchell	"	Trap rock	3	Orange Mt., N. J		Archa	Presented by N. H. Winchell.		
5562	"	"	"	Felsyte	3	High Rock, Lynn, Mass			"	"	
5563	"	Geol. and Nat. Hist. Survey	"	Silicified fossils, from the Cret. conglomerate	31	Red Jacket Bridge, nr. Mankato			N. H. Winchell.		
5564	"	"	"	Series showing passage from magnesian schist to hematite	4	Vermilion iron mines		Archa	"		
5565	"	Geo. C. Stone	"	Hematite, from Stuntz mine	1	"	"	"	Presented by Geo. C. Stone.		
5566	"	"	"	" " Ely mine	1	"	"	"	"	"	
5567	"	"	"	" " Stone mine	1	"	"	"	"	"	
5568	"	"	"	" " Lee mine	1	"	"	"	"	"	
5569	"	"	"	" " Tower mine	1	"	"	"	"	"	
5570	"	"	"	" " Breitung mine	1	"	"	"	"	"	
5571	"	"	"	" " Armstrong mine	1	"	"	"	"	"	
5572	"	D. S. Martin	"	Lignite	4	Disco Island, Greenland			"	D. S. Martin.	
5573	"	"	"	" mainly organic	2	Bahia, Brazil			"	"	(Used for making gas New York.
5574	"	Geo. F. Kunz	"	Native antimony	1	Prince William, York co., New Brunswick			Presented by Geo. F. Kunz.		

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1884.—(Continued.)

Serial Number.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
5575	1884.	A. A. Julien.....	Sonorous sand.....	.....	Atlantic shore	.....	Presented by A. A. Julien.
5576	"	B. Juni.....	Wood from a well 116 feet deep.....	Ind.	New Ulm, Minn	Drift	" B. Juni.
5587	Aug., 1884.	B. W. Thomas.....	Sporangites Huronensis, Daw.....	"	Chicago, Ill.....	Devon	" B. W. Thomas, Chicago, boulder clay.
5588	Dec., 1884.	A. W. Barber.....	Crocidolite	1	South Africa.....	.....	Presented by A. W. Barber.
5589	June, 1884.	Prof. W. F. Phelps..	"White iron" and arsenical sulphuretes, carrying gold	1	Bear Gulch, Mont.....	.....	" Prof. W. F. Phelps.
5590	"	" "	Lava from H. O. W. copper mine	1	Black Hills, Dak.....	.....	" "
5591	"	" "	Gold bearing quartz, carrying iron pyrites..	1	Bear Gulch, Mont.....	.....	" "
5592	"	" "	Silver ore (sulphide)	1	Vienna Mine, Idaho	.....	" "
5593	"	" "	Silver sulphide.....	1	" "	.....	" "
5594	"	" "	Argentiferous galena.....	1	Black Hills, Dak.....	.....	" "
5595	"	" "	Galena and silver ore.....	2	Near Malden, Mont.....	.....	" "
5596	"	" "	Galena and silver	1	Concord mine, Maine.....	.....	" "
5597	"	" "	Argentiferous galena.....	1	Montana.....	.....	" "
5598	"	" "	Copper bearing quartz	1	Belt Range, Mont.....	.....	" "
5599	"	" "	Oxide copper.....	3	Black Hills, near Sheridan, Dak	Cup.....	" "
5600	"	" "	"	1	Black Hills, Dak.....	"	" "
5601	"	" "	Carbonate copper in quartz	2	Belt Mts., Mont., near Livingston.....	"	" "
5602	"	" "	Carbonate copper.....	4	Black Hills, n'r Sheridan.	"	" "
5603	"	" "	Green carbonate and oxide of copper.....	2	Black Hills, Dak.....	"	" "
5604	"	" "	Carbonate of copper from shaft 25 feet	11	" "	"	" "
5605	"	" "	" " from open cut.....	8	" "	"	" "
5606	"	" "	.....	1	Belt Mts., Mont	.....	" "
5607	Jan., 1884.	Presented.....	White sandstone.....	2	Lansing, Iowa	.....	" by J. M. Turner.
5608	1884.	" "	Group of quartz crystals.....	1	Ozark Mts..	.....	" Hon. Richard Chute, obtained at Hot Springs.
5609	Sept., 1883.	Geol. and Nat. Hist. Survey.....	Darkish gray, shaly, siliceous, and probably dolomitic. First well.....	1 bottle.	St. Paul, Minn.....	———	W. Upham (500–525–582 feet.)
5610	"	" "	The same. First well.....	"	" "		" No. 2 (500–525–582 ft).

5611	"	"	"	" "	"	"	"	Drillings from the Harvester Works Well.	"	(582–592 feet.)
5612	"	"	"	" "	"	"	"		"	(592–602.)
5613	"	"	"	" "	"	"	"		"	(602–612.)
5614	"	"	"	" "	"	"	"		"	(612–626.)
5615	"	"	"	Dark, sandy, and clay loam. Second well	"	"	"		"	(1–10 feet.)
5616	"	"	"	Gray sand and fine gravel. Second well	"	"	"		"	(10–20.)
5617	"	"	"	Same, with pebbles up to 1½ in. diam. Second well	"	"	"		"	(20–30.)
5618	"	"	"	Yellowish, coarse sand. Second well	"	"	"		"	(30–40.)
5619	"	"	"	Yellowish sand and gravel. Second well	"	"	"		"	(40–50.)
5620	"	"	"	The same (fine gravel). Second well	"	"	"		"	(50–60.)
5621	"	"	"	Light gray sand and fine gravel. Sc'nd well	"	"	"		"	(60–70.)
5622	"	"	"	The same. Second well	"	"	"		"	(70–80.)
5623	"	"	"	The same. Second well	"	"	"		"	(80–90)
5624	"	"	"	Light gray, fine sand and pebbles, 1½ in. diam. Second well	"	"	"		"	(90–100.)
5625	"	"	"	The same, with pebbles ¾ in. Sc'nd well	"	"	"		"	(100–110.)
5626	"	"	"	Light gray sand and gravel. Second well	"	"	"		"	(110–120.)
5627	"	"	"	The same. Second well	"	"	"		"	(120–130.)
5628	"	"	"	The same (gravel fine). Second well	"	"	"		"	(130–140.)
5629	"	"	"	Light, reddish gray sand, with pebbles. Second well	"	"	"		"	(140–150.)
5630	"	"	"	The same, with pebbles 2 in. in diam. Second well	"	"	"		"	(150–160.)
5631	"	"	"	The same, with pebbles up to 1½ in. Second well	"	"	"		"	(160–170.)
5632	"	"	"	Light gray sand, with pebbles 1 in. in diameter. Second well	"	"	"		"	(170–180.)
5633	"	"	"	Coarse gravel. Second well	"	"	"		"	(180–190.)
5634	"	"	"	Similar to last, but with more sand. Second well	"	"	"		"	(190–200.)
5635	"	"	"	Same, mostly finer. Second well	"	"	"		"	(200–210.)
5636	"	"	"	Same, with pebbles up to 2 in. diam. Second well	"	"	"		"	(210–220.)
5637	"	"	"	Yellowish sand, with few gravel stones. Second well	"	"	"		"	(220–230.)
5638	"	"	"	Fragments of a buff magnesian limestone, with some sand and gravel. Scnd well	"	"	"		"	(230–240.)
5639	"	"	"	Limestone, light yellowish. Second well	"	"	"		"	(240–250.)
5640	"	"	"	Limestone, light buff. Second well	"	"	"		"	(250–260.)
5641	"	"	"	Similar to last. Second well	"	"	"		"	(260–270.)
5642	"	"	"	Light buff magnesian limestone. Sc'nd well	"	"	"		"	(270–280.)
5643	"	"	"	Yellowish buff magnesian limestone. Second well	"	"	"		"	(280–290.)
5644	"	"	"	Yellowish powder, with fragments of magnesian limestone. Second well	"	"	"		"	(290–300.)
5645	"	"	"	Mostly fine, light gray powder, with fragments of magnesian limestone. 2d well	"	"	"		"	(350–360).

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SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1884.—(Continued.)

Serial Number.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
5646	Sept., 1883.	Geol. and Nat. Hist. Survey	Sandstone, light yellowish, with dolomitic powder. Second well	1 bottle.	St. Paul, Minn	Drillings from the Harvester Works Well.	W. Upham (360–370.)
5647	"	" "	Limestone, light yellowish buff. Sc'nd well..	"	" "		" (370–380.)
5648	"	" "	Sandstone, light gray. Second well	"	" "		" (380–390.)
5649	"	" "	Same, with pieces of coal, metallic iron, and furnace slag. Second well	"	" "		" (390–400.)
5650	"	" "	Same, with coal and battered scales of metallic iron. Second well	"	" "		" (400–410.)
5651	"	" "	The same as last. Second well	"	" "		" (410–420.)
5652	"	" "	Same, but finer and white, with some pyrite and few iron scales. Second well	"	" "		" (420–430.)
5653	"	" "	Same, with slight traces of coal and iron scales. Second well	"	" "		" (430–440.)
5654	"	" "	Same as last. Second well	"	" "		" (440–450.)
5655	"	" "	Sandstone, fine, water-worn. Second well..	"	" "		" (450–460.)
5656	"	" "	" coarse, yellowish gray. 2d well..	"	" "		" (460–470.)
5657	"	" "	" very fine, light yellow. 2d well..	"	" "		" (470–480.)
5658	"	" "	Sandstone, very fine, light, leaden gray. Second well	"	" "		" (480–490.)
5659	"	" "	Sandstone, very fine, light, dusky gray. Second well	"	" "		" (490–500.)
5660	"	" "	Sandrock, gray, compact, and hard, probably dolomitic. Second well	1	" "		" 6 in. of core at 555 ft.
5661	"	" "	Same as the preceding. Second well	3	" "		" 18 in. of core at 578 ft.
5662	"	" "	Sandrock, light, yellowish buff. Sc'nd well.	2	" "		" 12 in. of core at 590 ft.
5663	"	" "	Similar to the last. Second well	9	" "		" 11 in. of core at 626 ft.
5664	"	" "	Sandrock, hard and compact, with layers of dark green sand. Second well	17	" "		" cores f'm 650 to 660 ft.
5665	"	" "	———. Second well	28	" "		" cores, depth not k'wn.
5666	1884.	Presented	Cretaceous leaves	13	Mankato, Minn	Cret.	From Mr. S. F. Alberger.
5699	"	By purchase	Felsyte	1	Minneapolis, Minn	Drift	" W. Howling.
5700	"	"	Asaphus megistos	1	Butler co., O		Prof. C. W. Hall. Cast.
5702	Oct., 1884.	By exchange	Lingula melie, Hall	1	Licking co., O	Cuyahoga sh.	From Prof. C. L. Herrick.

5703	"	"	"	Lycopodites vanuxemi, Dow	1	Ithaca, N. Y.	Chemung	"	"	
5704	"	"	"	Streptelasma corniculum, Hall	1	Dayton, O.	Tr'n & Hud.	"	"	
5705	"	"	"	Pentamerus oblongus, Sowerby	2	Springfield, Clark co.	Niagara	"	"	
5706	"	"	"	Strophomena alternata, Conr	3	Cincinnati, O.		"	"	
5707	"	"	"	Leptæna sericea	2	Dayton, O.		"	"	
5708	"	"	"	Allorisma Winchelli, Meek	2	Rushville, O.		"	"	
5709	"	"	"	Sanguinolites obliquus	2	"		"	"	
5710	"	"	"	Sperifera mucronata (?)	1	Ithaca, N. Y.	Chemung	"	"	
5711	"	"	"	Rhynchonella dentata, Hall	2	Dayton, O.	Cincinnati.	"	"	
5712	"	"	"	" increbescens	2	"	"	"	"	Lebanon beds.
5713	"	"	"	" "	3	Cincinnati, O.		"	"	
5714	"	"	"	Orthis biforata	2	"		"	"	
5715	"	"	"	" occidentalis, Hall (?)	2	"		"	"	
5716	"	"	"	Streptelasma corniculum, Hall	1	"		"	"	
5717	"	"	"	Grammysia ventricosa, Meek	1	Rushville, O.		"	"	
5719	"	Presented		Endoceras proteiforme, Hall	1	Warren co., O.		From Prof. C. W. Hall.		
5720	"	"		Orthis acutilirata, Conr	3	Butler co., O.		"	"	
5721	"	"		Rhynchonella capax, Conr	3	"		"	"	
5722	"	"		Zygospira cincinnatensis	6	"		"	"	
5723	1884.	Geol. and Nat. Hist. Survey		Rusted stone	1	Minneapolis, Minn.		N. H. Winchell.		(At 135 feet.)
5724	"	"	"	Quartzose sandstone, composed of rounded grains of pure quartz	Ind.	"	"	Drillings from the Lakewood Cemetery Well.	"	(256–276 feet.)
5725	"	"	"	The same	"	"	"		"	(276–296 feet.)
5726	"	"	"	The same	1 bottle.	"	"		"	(At 300 feet.)
5727	"	"	"	The same	"	"	"		"	(At 314 feet.)
5728	"	"	"	Dolomitic rock (washed)	"	"	"		"	(318–320 feet.)
5729	"	"	"	Sand	"	"	"		"	(At 320 feet.)
5730	"	"	"	White sand	"	"	"		"	(At 325 feet.)
5731	"	"	"	Slightly red, fine grained, dolomitic rock	Indif.	"	"		"	(360–403 feet.)
5732	"	"	"	The same, with some mixture of the next (No. 5733)	"	"	"		"	(403–416 feet.)
5733	"	"	"	Translucent rounded grains of quartz	"	"	"		"	(416–424 feet.)
5734	"	"	"	The same	"	"	"		"	(424–434 feet.)
5735	"	"	"	White chert, coated with dolomitic pyrites	"	"	"		"	
5736	"	"	"	White quartz sand, rounded	"	"	"		"	(434–481 feet.)
5737	"	"	"	The same, with traces of light, green shale	"	"	"		"	(481–504.)
5738	"	"	"	White quartz sand, rounded, with some green shale	"	"	"		"	(504–558.)
5739	"	"	"	White sand and green sand	"	"	"		"	(558–607.)
5740	"	"	"	White sand	"	"	"		"	(694–704.)
5741	"	"	"	Mainly white sand	"	"	"		"	(763–773.)
5742	"	"	"	Green clay or shale, non-effervescing, very fine grained	"	"	"		"	(780–844.)
5743	"	"	"	White sand, with a faint, yellowish tint	"	"	"		"	(935–960.)
5744	"	"	"	Siliceous sand, with a faint, pinkish tint, rather fine	"	"	"		"	(1005–1010.)

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1884.—(Continued.)

Serial Number.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
5745	1884.	Geol. and Nat. Hist. Survey	Siliceous sand, with a deeper pinkish tint and coarser grain	Indif.	Minneapolis, Minn.	Drillings from Lakewood Cemetery Well.	N. H. Winchell. (1010–1050.)
5746	"	" "	The same, but of a lighter color	"	" "		" (1060–1070.)
5747	"	" "	The same, but cemented, when dry, with ground up reddish shale	"	" "		" (1105–1120.)
5748	"	" "	Compact red clay or shale	"	" "		" (1123–1160.)
5749	"	" "	Sand shale of a reddish color	"	" "		" (bet. 1123–1167)
5750	"	" "	Red shale, mottled with light green	4	" "		" (bet. 1123–1167)
5751	"	" "	Reddish brown shale	Indif.	" "		" (1167–1235.)
5752	"	" "	The same	"	" "		" (1235–1260.)
5753	"	" "	The same	"	" "		" (1260–1365.)
5754	"	" "	The same	"	" "		" (At 1400 feet.)
5755	March, 1885.	" "	Gray, tough cryptocrystalline, similar to survey No. 469 or 473	"	" "		" (At 1860 feet.)

Archæological specimens registered in the General Museum in 1884.

112. Flints (three) from about lake Minnewaska, Minn. Presented by Dan. F. Bartke, of Glennwood, Minn., March 14, 1884.

113. One piece of obsidian from lake Minnewoska. Presented by Dan. F. Bartke, of Glennwood, Minn., March 14, 1884.

114. Bit of red substance from stratum, Little Falls, Minn. Presented November 10, 1882, by Frances E. Babbitt.

115. One piece of sonorous *quartz* from stratum, Little Falls, Minn. (they jingle with other *quartz*-like metal). Presented November 10, 1882, by Frances E. Babbitt.

116. Chipped implement (one), from river gravels at the ferry, Little Falls, Minn. Presented November 10, 1882, by Frances E. Babbitt.

117. Piece of nicked *quartz*, perhaps for cutting tendons, etc., from stratum, Little Falls, Minn. Presented November 10, 1882, by Frances E. Babbitt.

118. Piece of a bone. Little Falls, Minn. Presented, November 10, 1882, by Frances E. Babbitt.

119. A small dark chert arrow point, one and a half inches long, notched base. From Battle Creek, Mich. Presented by Mrs. C. H. Crosby, 1883.

120. Arrow point (one), light chert, three and a quarter inches long, notched base. From Battle Creek, Mich. Presented by Mrs. C. H. Crosby, 1883.

121. Gray flint implement (one), four and a half inches long, rounded base. From Battle Creek, Mich. Presented by Mrs. C. H. Crosby, 1883.

122. Stone hammer (one). Sample of those now in use among the Cheyenne Indians, near the Black Hills. Presented by the Rev. L. J. Hauge, Mankato, 1883.

123. Spear head (one), dark chert, four and three-quarter inches long, pointed at both ends. From section 30, township 45, range 28, west of Mille Lacs, Minn. Presented January 5, 1884, by O. E. Garrison.

124. Specimens of pottery (forty-five pieces), from Mille Lacs, Minn. Presented January 5, 1884, by O. E. Garrison.

125. Piece of flint (one) from Mille Lacs, Minn. Presented January 5, 1884, by O. E. Garrison.

126. Implement of brown chert (one), from Mille Lacs Minn. Presented January 5, 1884, by O. E. Garrison.

127. Stone implement (one), from Mille Lacs, Minn. Presented January 5, 1884, by O. E. Garrison.

128. Specimen of tattooing taken from the arm of a cadaver. Presented by Dr. Arthur Eastman.

129. Stone hammer (one), from Illinois. By purchase from Wm. Howling, 1884.

130. Stone hammers (two), from Long Lake, Minnesota. By purchase from Wm. Howling, 1884.

List of books added to the Library of the Geological and Natural History Survey since the publication of the list in the report of 1880.

Proceedings of the Academy of Natural Sciences, of Philadelphia. Parts I and II, January to October, 1879. Purchased.

Proceedings of the Davenport Academy of Natural Sciences. Volume III, Parts II and III, 1879-81. From the Academy.

Transactions of the Edinburgh Geological Society. Volume IV, Part II, 1881-82. Purchased.

Bulletin of the Buffalo Society of Natural Sciences. Volumes I, II, III and IV. Complete. From the Society.

The American Antiquarian and Oriental Journal. Volume IV, No. 1, October, 1881, and No. 4, October, 1882. Volume V, complete. Volume VI, Nos. 1, 3, 4 and 6, 1884. Volume VII, Nos. 1 and 3, January and March, 1885. From the Editor.

Bulletin of the United States Geological Survey. No. 1, 1883. From the Survey.

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XII.

NOTES ON THE GEOLOGY OF MINNEHAHA COUNTY, DAKOTA.

BY WARREN UPHAM.

Typical Potsdam quartzyte outcrops one mile southeast of Dell Rapids (which is on the Sioux river, some fourteen miles west from the northwest corner of Rock county), dipping about 2° south, 35° west (as referred to the true meridian). *Glacial striæ*, well shown at this place, bear south 25° to 30° east. (This locality, like the mound, is beyond the limits of the ice of the last glacial epoch, and therefore these striæ were formed by the earlier ice-sheet. When that ice-sheet terminated beyond the Missouri river in Nebraska and Kansas, we cannot doubt that the ice current moved nearly from north to south upon all this region midway between the west border of the ice and the driftless, never ice covered, area of Wisconsin and southeastern Minnesota; but the prevailing striation at the mound and the pipestone quarry bearing southwesterly, and of this locality near Dell Rapids bearing southeasterly, demonstrate that during the final melting and recession of that earlier ice-sheet it became in this portion lobed, with different slopes of its surface and different directions of the motion of its ditsinct lobes and their various portions, principally (as I believe) produced by meteorological conditions, nearly as the terminal moraines of the last ice-sheet show that it, in the later glacial epoch, was lobed and had different directions of motion in its different parts upon areas not more than twenty-five miles distant from these localities toward the northeast and northwest. (See plate VI, in the *Ninth annual report*). *Ripple-marks* are occasionally seen on the quartzyte at this outcrop. This rock is here visible in low exposures, extending an eighth of a mile, along a northwardly sloping slight depression excavated by drainage.

Quartzyte also outcrops one mile due east of Dell Rapids, on the east side of the Big Sioux river (commonly called simply "Sioux river"); and again, one and a half miles north of Dell Rapids, on section three, about one and a half miles west of the river. These are its most northern exposures that I heard of in this region. No fossils, no pipestone, and no conglomerate portions, are known in this quartzyte.

Water power. William Van Eps, Dell Rapids (s. ½ of sec. 9); Dell Rapids mills; fall, eleven feet, with right to increase to fourteen. The fall in the Sioux river, at and below Dell Rapids, from Van Eps' pond (which holds the river as back-water to a distance of three miles), to a point one and a half miles south of the junction of the "Dells" channel, or about four miles south of Dell Rapids village, is approximately twenty-five feet. At Mr. Van Eps' present hight of flowage, a dam about three feet high has to be provided to turn the water of this pond in the Sioux river from running into the "Dells" channel; but before the mill dam was built the stage of low water at the bridge at Dell Rapids was about six feet lower than the divide between it and the "Dells." This sketch, figure eight (I have no good map), will serve to give some idea of the relative position of the localities mentioned.

FIG. 8.

"*The Dells.*" The Sioux river, after passing the village of Dell Rapids, first runs westerly a half mile, more or less, and then flows south, inclosed by walls of Potsdam quartzyte. Another rock-walled channel of the same kind, called the "Dells," already several times referred to, extends south from near the bridge in Dell Rapids village. It is thus east of the present course of the Sioux river at its ordinary stage, but a large part of the river flows through this channel at its times of flood. The picturesque rock gorge called the "Dells" extends about one and a half miles in rock, from near the river at Dell Rapids village to the south; and this channel is said to continue across the alluvial bottom-land about one and a half miles further before joining the present channel of the Sioux river. The highest walls of this gorge are within three-quarters of a mile south of Dell Rapids, along which distance they rise vertically on each side 30 to 40 or 50 feet above the still water that fills the bottom of the gorge along a distance of one and a quarter miles, varying in width from three to five rods, and ten to twelve feet deep. The rock here is typical quartzyte, dipping two or three feet in a hundred, or

about one degree, to the south-southwest. This quartzyte is bedded in layers from a few inches to one foot or rarely two feet thick, and is intersected by very numerous vertical or nearly vertical joints, which often divide it into rhomboidal fragments only from three to six inches or a foot long. The surface of the bedding-planes is frequently ripple-marked. No glacial striæ were found here; all the rock surface appears somewhat water-worn. The erosion of this channel has been facilitated by the jointed structure of the rock, and both this and the channel now occupied by the river have probably been eroded by this stream since the ice age.

This quartzyte is mostly very hard and of a reddish gray color, about as at its exposures near New Ulm, in Cottonwood county, and in Pipestone and Rock counties. At the quarry on the east side of the "Dells," near their south end, a mile south of Dell Rapids village, the color of this stone is light gray, slightly tinged toward pink. Rarely it occurs with a quite soft, somewhat friable texture, as was found in a well at Dell Rapids. This rock is seen in frequent low outcrops for about a mile south from the south end of the "Dells," beyond which no rock-outcrops were learned of in the next fifteen miles southward, their next occurrence being at Sioux Falls.

The gorge through which the Sioux river flows, close below Mr. Van Eps' mill, or about a mile southwest from Dell Rapids village, is said to be inclosed by vertical walls of the quartzyte, some fifteen feet high. In this channel three remnants of the rock stand up like bridge piers, having the same hight as the rock on each side. The whole thickness of the Potsdam quartzyte exposed at Dell Rapids is about seventy-five feet; it cannot exceed one hundred feet. Its top here may be one hundred feet above its top at Sioux Falls; this estimate being dependent mainly on another, namely, that the river at Dell Rapids is seventy-five feet above Emerson, Sherman & Co's mill pond at Sioux Falls.

Bottomland from one to two miles wide borders the Sioux river from a point one and a half miles south of Dell Rapids to Sioux Falls. Its hight is about ten feet above the river, by which it has been overflowed three times during the past eleven years. The surface at each side is moderately undulating till, with swells 25 to 40 feet above its depressions, the hight being 50 to 90 feet above the river and the bottomland.

Nils B. Peterson's well; northwest quarter, Section 3, T. 102, R. 49 (nine miles north of Sioux Falls), well, 30 feet; soil, 2; yellow

till, spaded, 5 feet; sand, 3 feet, yielding the only water found; very hard blue till, picked, 21 feet, and extending lower; water a plenty for house and twenty cattle. The till here and generally in this region, contains as large a proportion of gravel and boulders (varying in size from a few inches or one foot to five feet in diameter) as is usually found in the till of southern and western Minnesota.

Pipestone, similar to that of the famous pipestone quarry in Minnesota, is reported as occurring eight miles distant, nearly due west from Mr. Peterson's (therefore about 12 miles northwest from Sioux Falls), or four miles west of New Hope post office, on Skunk creek in the northeast part of T. 102, R. 51. Much of this pipestone is red, other portions are mottled or sometimes nearly cream-colored, as at the Indian pipestone quarry. It has been whittled into pipe bowls and various trinkets. It is hard at the surface, but softer within; and is thought to form a layer four feet or more in thickness, inclosed in the quartzyte. It has been used to build chimneys, where it does not crack and crumble like the quartzyte.

Sioux Falls. The Potsdam quartzyte is next found exposed in low outcrops about two miles west of Sioux Falls, on the broad bottomland of the Sioux river. The valley eroded in the thick sheet of glacial drift by this river below (eastward from) Sioux Falls is about a mile wide and inclosed by bluffs 100 feet or more in hight on its north side, and from 125 to 150 feet (probably nearly 200 feet at three miles east of Sioux Falls) in hight on its south side; these bluffs being steep, with more knolls, buttresses and ravines than usual (as, for example, on the Minnesota river), making a quite picturesque view as seen from a point a mile north of Sioux Falls, looking eastward and southward. This valley is eroded through till, which in some places was seen to be thinly covered by loess, nearly as in southwestern Rock county, and elsewhere, more rarely, by deposits of gravel and sand; the quartzyte of this vicinity is exposed only in the bottom of the valley, and ends in low outcrops about a half mile below (north and northeast of) Sioux Falls.

Mr. William Van Eps, of Sioux Falls (owner of mill at Dell Rapids), reports outcrops of quartzyte (nearly like that at Sioux Falls) on the James river at Rockport in Hanson county and again in the same county seven miles further north (a few miles below Firesteel, a place formerly important but whose glory has de-

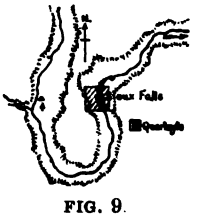


FIG. 9.

parted, eclipsed by Mitchell, three miles distant to the west;) but he thinks this rock has no other exposures on the James river. About fifteen miles east of Mitchell, good quartzyte for quarrying occurs on Pier creek, where it is crossed by the railroad and further north. I think that this quartzyte is reported by Hayden on the east and west Vermilion rivers, in McCook county.

Water power at Sioux Falls. Three dams and mills are here located on the Sioux river:

1. Cascade mills; the upper mill, Emerson, Sherman & Co.: fall or head, 10 feet, flowing the river back about two miles.

2. Queen Bee mill; Sioux Falls Water Power company: head, 56 feet; this mill (built, if I rightly remember, of the quartzyte of this vicinity) is 80x100 feet in dimension, and seven stories (106 feet) high; its walls are 5 feet 4 inches thick at the base, and 2 feet 6 inches at the top.

3. Sioux Falls mills; the lower mill; Webber, Shaw & Watson: head, 14 feet. This lowest mill is not more than a half mile below (north of) the upper mill. There may be five feet of fall lost between these mills; but I think less, or none. The total fall within the city limits (section 16) is said to be 85 feet, which must be nearly or quite correct. If a canal were cut across the base of the river's extensive circuit west of Sioux Falls, excavating about ten feet deep across bottom land for a mile, and some 30 feet in depth for a quarter of a mile through the ridge of drift which extends southward in the west edge of the city, it is said that a fall of about 110 feet in total, or 25 feet more than now, would be obtained.

The rock of Sioux Falls is the typical Potsdam quartzyte, similar in texture, hardness, color (usually reddish-gray), bedding (frequently ripple-marked), and joints, with its outcrops in Nicollet, Cottonwood, Pipestone and Rock counties, and at Dell Rapids. Its dip varies from a half degree to two or three degrees, or a descent varying from one to five feet in a hundred, toward the south and south southwest. Allowing for its dip, the whole thickness of this rock exposed at Sioux Falls is approximately 125 feet; it cannot exceed 150; it nowhere rises much (not more than 20 or 30 feet) above the river at the head of the falls.

Quarries of this stone have been worked in small amount two miles west of Sioux Falls; two miles south of this city on the left (there north) side of the Sioux river, about a half mile from

it, this quarry yielding good stone; and, most of all, in the north part of Sioux Falls corporation. Hayden (in the *Am. Jour. of Sci. and Arts*, for Jan., 1867) says, in describing this formation at Sioux Falls: "About ten feet from the top of the rocks as seen at this locality, is a layer of steatitic material, mottled, gray and cream color, very soft, about 12 inches thick, which is used sometimes for the manufacture of pipes and other Indian ornaments. * * * There are also beds of pudding stone, and the most beautiful illustrations of wave and ripple markings that I have ever observed in my geological explorations."

Glacial striæ. The surface of nearly all the quartzyte exposed at Sioux Falls is so waterworn that its glacial marks have been effaced. Considerable search afforded me only the following observations: About 20 to 25 rods north of the St. Paul & Sioux City (C., St. P., M. & O.) railroad depot, glacial striæ, seen in a half dozen or more places, mostly bear uniformly S. 40° E. (referred to the true meridian, allowing 10° for the needle's variation east of north); but on one surface here, six feet square, situated 10 to 50 feet distant from foregoing glaciated places, are very clear glacial striæ, bearing due east. About a dozen rods northeast from these, striæ were again found, on a smooth surface of rock about ten feet in extent, where they vary in their direction from due south to S. 25° E., these courses being seen on the same surface crossing each other. For the reasons set forth on pages 505 and 549, of vol. 1, final report, it is probable that the striæ bearing south are the oldest, and that the striæ bearing southeasterly and east are records of a progressive deflection here of the ice-current toward the east, by the formation of a lobe in the ice-sheet of this first glacial epoch during its recession. How this would take place will be understood by referring to Plate VI, in the *Ninth annual report.*

Terraces. During the river's excavation of its valley in the thick drift-sheet along the first six miles east of Sioux Falls, a well-marked terrace-plane was formed 60 to 75 feet above the present channel, portions of which remain as follows: One, about two miles long and 20 to 40 rods wide, on the northwest side of the river, 2 to 4 miles northeast from Sioux Falls; another, one and a half miles long and 30 to 60 rods wide, situated on the south side of the river, about 3½ to 5 miles northeast of Sioux Falls; and a third, or perhaps several, seen in the view down the valley within a few miles further southeastward. The first of these terraces, and probably the others, consists of till,

with frequent boulders on its escarpment or face, and in some places on its flat surface above; but mostly this upper surface is thinly covered with fluvial deposits of gravel and sand.

Contour. Lakes and sloughs are rare or absent in all this region; I saw none. The surface is very smooth till, seldom having any covering of loess. The contour of this drift-sheet is quite different from that found upon the regions that were overspread by the last ice-sheet; but closely resembles that of Pipestone and Rock counties. It is characterized by massive swells of varying hight, tending mostly from north to south, or more so than in other directions. The separate swells are usually from 25 to 50 feet above the intervening hollows or depressions; while areas a few miles apart vary sometimes 100 or 150 feet in their average hight. No drift deposits marked by the peculiarly rough and broken contour of our terminal and medial moraines were found in this region.

Palisades post-office, store, and mill are in sections 30 and 31, T. 103, R. 47, at the middle of the south side of section 30, about four miles west from the state line of Minnesota. The "palisades" extend from the dam a half mile southwestward, the Split Rock creek being confined along this distance between vertical walls of the Potsdam quartzyte, 40 to 60 feet high, and from 50 to 150 feet apart. A "rock island" rises like a tower in the middle of this gorge, about 20 rods south of the mill, and 60 feet high, its top being seen with that of the walls at each side, which here attain their greatest altitude.

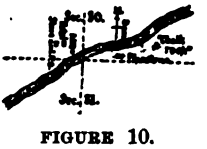


FIGURE 10.

Palisades mill, C. W. Patten; fall, 23 feet; cable to mill, 212 feet; hight from stream below the wheel to the mill, 55 feet. Split Rock creek is said to descend 72 feet in its four miles next above the southwest (lower) end of the Palisades.

The rock here is the typical red Potsdam quartzyte, dipping two to three degrees, or about four to six feet in a hundred, to the south-southwest. This formation embraces in this vicinity two layers, each several feet thick, of compact, fine-grained, red rock, easily cut and polished, closely resembling the catlinite of the Pipestone quarry in Minnesota. The upper one of these layers is seen a quarter of a mile southwest from the mill on the northwest side of the creek, where it has been quarried and is called "slate." Its vertical exposure in the quarry is seven feet, but its base, though probably not much deeper, is not seen.

It lies in sheets from an eighth of an inch to six inches thick, dipping about two degrees S. 30° W. The plane of this bed, prolonged northeastward, passes just above the top of the Palisades. The lower one of the two layers mentioned is called "pipestone," and is scarcely inferior in quality to that of the Indian quarry in Pipestone county. This bed is exposed about five rods south of the dam and some thirty rods east of the mill, where it is seen to have a thickness of at least four feet (it may be as much as seven feet thick) divided in sheets, from a half inch to three or four inches thick. It here dips 6° or 7°, or ten or twelve feet in a hundred, S. 60° W. The unusual steepness of this dip, as compared with the average and nearly uniform dip of the whole formation in this locality, is doubtless due to a local displacement of very small extent; for the floor of quartzyte, on which this pipestone lies, varies in its inclination, within three or four rods away from this bed, to the average dip of about two degrees. At the bottom of the wheel-pit of the mill, 30 rods west from this pipestone quarry, the top of this pipestone layer, having the same fine quality, was excavated to a depth of six inches. The top of this layer in the wheel-pit was 12 or 14 feet lower than its base at its exposure near the dam. This pipestone layer is thus contained in the quartzyte very nearly at the water-line of the creek in the Palisades, being 60 feet, approximately, lower than the similar bed called "slate."

Twenty rods east of the dam at the Palisades, and about 20 to 25 feet above this dam, is an excavation (made to get material for building the dam) into "chalk rock," which is thus exposed with a vertical thickness of four feet (though its base is not seen) and along an extent of about 50 feet, dipping the same as the quartzyte, about two degrees, or some four feet in a hundred, to the south-southwest. It occurs in sheets or layers, which vary from a quarter of an inch to two inches in thickness; and these are much traversed by joints, whereby this rock is divided into a multitude of small rhomboidal pieces, usually a few inches (seldom a foot) long. The upper part of this bed is soft, being scarcely harder than many shale beds, and is whitish, often quite white; it gradually changes below to a pinkish color, and at the same time becomes harder and exhibits fewer joints in its lower portion. In fineness and microscopic homogeneity of texture, it is closely like pipestone (catlinite), which it also probably resembles in chemical character (see Prof. Dodge's analysis, p. 203, *Tenth an. rep.*), not being calcareous, so that its

name, applied by Mr. Patten, is a misnomer. This "chalk-rock" is not seen in contact with the quartzyte or other bedded rocks; but its conformity in dip with the Potsdam formation, so extensively exposed in its immediate vicinity, makes it highly probable that it is a layer inclosed in the quartzyte. It lies in the line of continuation of the closely contiguous "pipestone," and may be only a changed portion of that bed, perhaps having come into its present condition by weathering. If this "chalk-rock" is ground to powder and then wetted, it dries in a hard mass, having about the same hardness as in its original bed.

The following is reported by Mr. C. W. Patten, of the Palisades: About six miles south of this place, or four or five miles above (N. N. E. of), the mouth of Split Rock creek, rock [Cretaceous?] in many respects similar to this "chalk-rock," perhaps harder, all of it whitish as the "chalk" is only at its top, occurs in thicker and more compact layers, and has been considerably used for building. It is cut into dimensions by a common saw; and in weight it is much lighter than the "chalk-rock" of the Palisades, so that a cord of it can be drawn by two horses. It forms a stratum at least eight feet thick, and is in layers from 4 to 8 or 10 inches thick; it is divided by joints with about the frequency desirable for convenience in quarrying. Its exposures (it is thought that the red Potsdam quartzyte is not seen in that vicinity), are between 5 and 20 feet above the Split Rock creek; and it is quarried at two places, or more, partly upon each side of the creek, which there is probably 75 feet lower than at the Palisades.

No such rock, nor anything comparable with it, is found associated with the Potsdam quartzyte, either in Dakota or Minnesota, north and northeast of the Palisades. No fossils have been seen in the "chalk-rock," nor in any portion of the Potsdam formation, at the Palisades, by Mr. Patten, who has excavated several hundred loads of the "chalk" for his dam. Excepting the beds thus called "slate," "pipestone" and "chalk-rock," the two former of which are clearly seen to be layers in the Potsdam formation, all the extensive exposures of its beds at the Palisades are the ordinary quartzyte, having its usual characters in respect to color, hardness, bedding and joints. No conglomerate was observed here; ripple-marks were seen on the bedding-planes in a few places. Rarely this stone, probably through the influence of weathering (perhaps in preglacial ages), has a soft and somewhat friable structure; this has been noticed

by Mr. Patten in some outcrops within a quarter of a mile from the Palisades; and four miles to the northeast a somewhat soft, pinkish sandstone (probably an altered form of this quartzyte) has been encountered in digging wells. The next exposures of the Potsdam quartzyte south of the Palisades are reported to be nine or ten miles distant, at the east side of the Sioux river, on the upland. Only a few miles further south, this quartzyte outcrops in the extreme northwest corner of Iowa.

The "Devils Gulch" is two and a half miles north-northeast from the Palisades and is a similar canon-like gorge, a half mile long, at the east side of Split Rock creek, on a trifling tributary. Its walls of rock are vertical, 30 to 50 feet high, and from 8 to 75 feet apart, with pools of water ten feet deep in the bottom of the gulch. The rock here is typical Potsdam quartzyte, dipping two and a half or three degrees (four to five feet in a hundred) towards the south-southeast, or, more exactly, S. 30° E. Here some parts of the walls, as also at Dell Rapids and the Palisades, are so intersected by vertical joints, nearly at right angles and from six inches to two feet apart, that the wall resembles ancient masonry, the separate rocks being rounded at the edge by weathering. It is also not uncommon to find places at the surface of this rock, where it similarly resembles the square paving blocks of stone sometimes used for streets. The Palisades and this Gulch seem to me equal in picturesqueness; both being worth going far to see, especially in this region of infrequent rock exposures.

No glacial striæ were observed at the Gulch nor at the Palisades.

XIII.

CHEMISTRY.

REPORT OF PROFESSOR DODGE.

THE UNIVERSITY OF MINNESOTA,
CHEMICAL LABORATORY.
MINNEAPOLIS, MINN., Oct. 6, 1884.

Professor N. H. Winchell,

DEAR SIR: I herewith report to you the results of the analyses made by the chemical department for the state geological survey since my last report. The present report comprises the analyses of nineteen siliceous rocks, numbered in the chemical series from 148 to 166 inclusive; also the analysis of a sample of impure graphite, and the analyses of two samples of water.

These analyses have been made almost wholly by Mr. C. F. Sidener, now instructor in the chemical department.

Very respectfully yours,
JAMES A. DODGE,
Prof. of Chemistry.

Chemical series No. 147. The water of Big Stone lake. The composition of the mineral matter dissolved in this water has been found to be as follows:

	Parts per million.	Grains per gallon.
Silica	106.50	6.2090
Carbonate of iron	2.20	.1283
Calcium carbonate	110.50	6.4455
Magnesium carbonate	63.00	3.6748
Magnesium sulphate	148.05	8.6358
Potassium sulphate	12.48	.7280
Sodium sulphate	95.63	5.5781
Sodium chloride	15.12	.8819
Phosphates	traces	
	553.48	32.2814

The amount of organic matter was such as to require 1.32 parts of oxygen per million parts of water for its oxidation. Yet this amount is not very excessive, being rather less than that in the Mississippi river just above this city.

The water is remarkable for the large amount of sulphates; also for a rather large proportion of silica.

RESULTS OF CHEMICAL ANALYSES OF SILICEOUS ROCKS.

CHEMICAL SERIES NOS. 148–166.

	Chemical series No. 148.	Chemical series No. 149.	Chemical series No. 150.	Chemical series No. 151.	Chemical series No. 152.	Chemical series No. 153.	Chemical series No. 154.	Chemical series No. 155.	Chemical series No. 156.	Chemical series No. 157.	Chemical series No. 158.	Chemical series No. 159.	Chemical series No. 160.	Chemical series No. 161.	Chemical series No. 162.	Chemical series No. 163.	Chemical series No. 164.	Chemical series No. 165.	Chemical series No. 166.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Silica, SiO_2	66.36	53.71	57.50	48.81	73.72	65.56	52.54	71.15	71.99	73.28	76.68	69.66	66.72	50.31	7..58	81.86	73.91	75.19	48.92
Alumina, Al_2O_3	13.33	14.96	13.29	23.27	12.82	10.06	13.50	12.40	12.36	11.83	12.14	11.49	7.41	14.17	13.36	9.87	14.89	10.78	18.45
Sesquioxide of iron, Fe_2O_3	7.89	14.45	11.62	11.80	2.51	14.40	15.35	5.21	4.99	4.61	3.16	3.95	10.13	10.96	3.78	1.44	2.27	4.01	16.88
Protoxide of iron, FeO	2.96	3.65	4.54	3.66	0.22	0.23	3.60	0.75	0.56	0.56	0.52	0.60	0.69	1.09	0.69	2.36	1.70	1.05	0.57
Lime, CaO	2.14	3.35	6.12	5.15	1.70	0.96	6.51	1.90	0.85	1.04	0.25	2.64	3.10	8.44	0.81	0.46	0.27	2.36	0.70
Magnesia, MgO	1.20	4.59	1.63	1.72	0.35	0.73	3.73	1.13	0.72	0.36	0.26	0.71	4.06	5.86	0.18	0.81	trace	0.95	3.68
Potash, K_2O	3.05	0.56	0.80	0.75	2.40	2.88	0.37	2.40	2.45	4.50	3.53	1.08	0.42	0.46	2.48	0.45	2.78	0.93	1.32
Soda, Na_2O	2.63	1.40	1.85	2.38	2.70	2.25	1.10	1.70	0.99	1.66	1.06	1.15	0.86	0.90	2.42	1.61	2.64	1.93	0.48
Water, H_2O	1.21	1.60	1.48	2.53	0.94	0.86	3.34	2.12	2.92	1.82	1.66	8.55	5.32	7.63	1.14	1.43	1.01	1.42	7.14
	100.77	98.27	98.83	100.07	97.36	97.93	100.04	98.81	97.83	99.66	99.26	99.83	98.71	99.72	98.44	100.29	99.47	98.62	98.14

Chem. series No. 167. Sample of impure graphite, from near Aitkin.

Carbon (graphite)	41.28 per cent.
Silica, SiO_2	43.23 "
Oxide of iron, Fl_2O_3	2.02 "
Alumina, Al_2O_3	10.70 "
Lime, CaO	0.46 "
Magnesia, MgO	0.05 "
Undetermined matter	2.26 "
	100.00

Chem. series Nos. 168 *and* 169. Brine from the Humboldt salt well.

Ingredients dissolved in the water.	Parts per million.	Grains per gallon, U. S.
Silica, SiO_2	208.5	12.15
Alumina, Al_2O_3	40.9	2.38
Carbonate of iron, $FeCo_3$	18.56	1.08
Sulphate of lime, $CaSo_4$	1,990.2	116.08
Sulphate of magnesia, $MgSo_4$	1,236.4	71.12
Carbonate of magnesia, $MgCo_3$	1,347.5	78.60
Chloride of magnesium, $MgCl_2$	1,567.6	91.44
Chloride of calcium, $CaCl_2$	2,684.0	156.55
Chloride of potassium, KCl	724.3	42.26
Chloride of sodium, NaCl	47,402.5	2,764.99
Phosphoric acid	traces.	.....
Total solids	57,220.46	3,336.65

Proportion of common salt, NaCl, in the total dissolved solids, 82.8 per cent. The samples from the depths of 180 feet and 450 feet were united, and the analysis above expresses the composition of the brine thus obtained. That from the depth of 450 feet was apparently some stronger in sodium chloride than that from 180 feet.

Chem. series, No. 170. Analysis of water of the Mississippi river taken at Brainerd:

Ingredients dissolved in the water.	Parts per million.	Grains per gallon U.S.
Silica, SiO_2	18.2	1.0616
Alumina, Al_2O_3	3.9	0.2275
Carbonate of iron, $FeCo_3$	4.205	0.2453
Carbonate of lime, $CaCo_3$	111.07	6.4787
Carbonate of magnesia, $MgCo_3$	27.72	1.6169
Carbonate of potash, K_2Co_3	6.0	0.3499
Carbonate of soda, Na_2Co_3	19.36	1.1292
Sulphate of soda, Na_2So_4	3.0	0.1749
Chloride of sodium, NaCl	1.5	0.0875
Nitrates	traces	traces
Phosphates	slight traces	slight traces
Total solids	194.955	11.3715
	Parts per million	
Oxygen required for the oxidation of organic matter by the permanganate test	1.28	

Chem. series, No. 171. Assay of a sample of ore for gold and silver.

Results: Gold none; silver none.

Chem. series, No. 172. Assay of a sample of ore for gold and silver.

Results: Gold none; silver $5\frac{4}{10}$ Troy ounces per ton of ore.

Chem. series No. 173. Supposed fossil shells in catlinite. (See before, page 103.)

NOTE.— The foregoing substances were derived as follows:

No. 147. Water from Big Stone lake, obtained by C. L. Herrick.

No. 148. Geol. survey number 1 B.; finely crystalline red syenite. Duluth.

No. 149. Geol. survey number 7; finely crystalline brown syenite. Duluth.

No. 150. Geol. survey number 19; crypto-crystalline, or amorphous, yet sparsely porphyritic with red feldspar and slightly amygdoloidal with epidote. Duluth.

No. 151. Geol. survey number 46; fine dark rock, thickly porphyritic with red feldspar, from Brewery creek. Duluth.

No. 152. Geol. survey number 68; "streamed," light red, metamorphic rock, with translucent laminations and specks. From near London.

No. 153. Geol. survey number 74; brick-red, rather fragile, apparently gritty and subcrystalline. At the mouth of Passabika river.

No. 154. Geol. survey number 117; "Two Harbor rock," crypto-crystalline, brown, conchoidal fracture, heavy.

No. 155. Geol. survey number 124; purplish red granite, from the west bluff at the entrance of Beaver bay.

No. 156. Geol. survey number 127; gray quartzyte, mouth of Beaver creek, Beaver bay.

No. 157. Geol. survey number 134; red granite, from the third island below Beaver bay.

No. 158. Geol. survey number 139; rock of the bulk of the Great Palisades.

No. 159. Geol. survey number 140; red, laminated, or "streamed," at the base of the Great Palisades.

No. 160. Geol. survey number 149; red, shaly, sandrock, associated with conglomerate, half a mile below the first falls of Baptism river.

No. 161. Geol. survey number 161, A; brown, aluminous vein-rock, crystalline (?), from trap-rocks at the town line between ranges 5 and 6 (on sec. 36), east of Pork bay.

No. 162. Geol. survey number 203; the red rock at Grand Marais, furnishing the pebbles of the beach.

No. 163. Geol. survey number 262; slaty, pinkish quartzyte, at the head of Wauswaugoning bay.

No. 164. Geol. survey number 285; red granite, from the first island N. W. from Belle Rose island, south of Pigeon point.

No. 165. Geol. survey number 555; red sandstone or quartzyte, fine grained, from the north side of Siskiwit point, Isle Royale, formerly quarried for building stone.

No. 166. Geol. survey number 809; red shale, from the quarry at Fond du Lac, resembling the pipestone of southwestern Minnesota, but softer and more sectile.

No. 167. Graphite from the vicinity of Aitkin, from Mr. —— Palmer, said to be from a well which struck the rock at 18 feet, situated two miles N. W. from Aitkin, apparently in a bed in the rock of the region.

No. 168. Brine from the Humboldt well, in Kittson county, from the depth of about 180 feet; artesian.

No. 169. Brine flowing from the large pipe at the Humboldt well, from the sandrock at the depth of 450-500 feet.

No. 170. Water from the Mississippi river at Brainerd, obtained by Dr. Howe in August.

No. 171. Iron ore, from Mayhew lake, north of Grand Marais.

No. 172. Rotted trap-rock, from T. 64.7 W., sec. 23, supposed to contain gold. From E. M. Fowler.

No. 173. Small slab of pipestone, Museum register number, 5,559; to scrape off the supposed fossil shells and test for phosphorus or lime.

N. H. WINCHELL.

XIV.

MINNESOTA GEOGRAPHICAL NAMES DERIVED FROM THE DAKOTA LANGUAGE, WITH SOME THAT ARE OBSOLETE.

BY PROF. A. W. WILLIAMSON.

[NOTE.—Pronunciation is indicated by respelling the word in a phonetic alphabet identical with that of Dr. Riggs' dictionary, except that the digraphs ch, gh, kh, sh, and zh, are used for his dotted c, g, k, s, and z, and only one form of n. A as in far; e as a in fate; i as in machine; o as in note; u as in rule; ch as in charm; kh as German ch; gh subvocal of kh, *i. e.*, continuant of g; zh as z in azure; t, k, p, w, h, s, and z as in English; b and m nearly as in English, but made nearer together; n and d approach each other still more, it being difficult for an unpracticed ear hearing some words spoken by some Indians to determine which of the two is used; n when it ends a syllable is sounded as Canadian *voyageurs* sound n in bon, much more strongly than the same sound is given by Parisians. Most Dakotas very slightly nasalize all their vowels, and in the case of a succeeded by k this nasalization is quite perceptible to a practiced ear; as, however, it is an entirely different sound from the nasal represented by n, it is obviously improper to confuse words by representing it in the same way, and being an accidental sound of no etymological value and scarcely perceptible in pronunciation, it does not seem desirable to represent it at all. That we should write Makato instead of Maŋkato is evident in this, that *maka* means earth and *maŋka* skunk, and no Dakota in saying blue earth would in any case use the strong nasal sound represented by n, and which if used would lead the hearers to suppose he meant, blue skunk. It is said that Fremont (Nicollet's map) wrote Mahkato and the h was changed to n by a broken type.]

Anoka (anoka),—on both sides; name applied by founders to the city laid out on both sides of Rum River, and since applied to the county.

Chaska (chaske),—first born child if a son; applied to the village by its founders.

Chapah (chapa),—beaver; the Dakota name of Beaver creek, a tributary of the Minnesota, and still retained on old maps.

Chanka sndatatah (chanka sdata),—*chan*, wood; ka, kindle;

sdata, feeble; the name applied to the Big Sioux river on Nicollet's map, as given by the Dakotas, but I think not in use of recent years. The Dakotas still call the Firesteel, a tributary of the James, or Dakota, Chanka.

Chanshayapi;—*chan*, wood; *sha*, red; ayapi, are on; Redwood river; so called by the Dakotas on account of the abundance of a straight slender bush with red bark, which they scraped off and smoked, usually mixed with tobacco. This name is spelled by Nicollet Tchanshayapi.

Chetanba wakpa (chetanbe wakpa),—*chetan*, hawk; *be*, nest; *wakpa*, river or creek; Hawk creek, a tributary on the north side of the upper Minnesota.

Cokato (chokata),— choka, the middle; ata, at; the name of a station on the Manitoba Railway.

Chokio (chokaya),— the middle; the name of a station on the H. &. D. Ry.

Dakota (dakota),—alliance league; the name by which the Dakotas called themselves; now applied to the territory, to a county, and to a village in Minnesota, etc. Lakota, a village in North Dakota, is the same word in the Titon form.

Eyota (iyotan),—greatest, most; name of a town in Olmsted county.

Hoghanwanke kin,—*hoghan*, fish; *wanke*, lies; *kin*, the; the place where the fish lies, the Dakota name of the St. Croix. For legend see Neil's *Minnesota*, p. 94.

Hokah (hutkan),— root; the Dakota name of Root river, retained on old maps, and now the name of a village in Houston county.

Imnizha ska,— *imnizha*, ledge; *ska*, white; the Dakota name of St. Paul, given on account of the white sandstone cropping out in the bluffs.

Intpah (intpa or inkpa,— k and t interchangeable before p),— end; the Dakota name of Lac qui Parle creek, flowing into the river at the end of the lake.

Inyan tankinyanyan,— *inyan*, stone; *tankinyanyan*, big; the Dakota name of Big Stone lake. The name is translated on Nicollet's and other old maps. It is so named on account of the large number of drift boulders along its shores.

Inyan sha,— *inyan*, stone; *sha*, red; the Dakota name of *Red Rock*, near St. Paul. A few rods from the river, near the house of Mr. Ford, an early settler, was a large egg-shaped syenite boulder, believed by the Indians to be the abode of a powerful

spirit, which they worshiped by keeping the stone carefully painted red, and by offerings of food. Every stone and every other natural object was believed by the Dakotas to be the abode of a spirit, but hard, egg-shaped stones only were worshiped.

Ipakshan,—crooked; *Mdeipakshan*, crooked lake, another name given to Big Stone lake, referring to its shape; *wakpa ipakshan*, crooked river; the Dakota name of the Big Sioux river.

Isantamde, knife lake; one of the Mille Lacs, found with variant spellings in the Dakota form, and translated, on old maps.

Isanti (isanati or isanyati),—*isan*, knife; *ati* dwell on or at; the Dakota name of the part of the nation occupying Minnesota, and comprising the Sissetons as well as those now known as Santees; it is supposed the name was given as this lake was their chief location for a time on their westward journey; the name of a county.

Ishtakhba,—*ishta*, eye, *khba*, sleepy; the name of an eminent Dakota chief, a firm friend to the whites, who was the first signer of the treaty of 1851. The name was probably applied to Sleepy Eye lake about 50 years ago, when his band planted there. Nicollet's map names it Sleepy Eye lake; it is now also the name of the village near it.

Iyedan (iyedan),—*mde*, lake; *iye*, speaks; *dan*, diminutive suffix, forms mdeiyedan, the Dakota name of Lac qui Parle, given as *iyedan* lake on old maps; it is very uncertain how it received the name; one tradition says from an echo on its shores; but it is doubtful if any such existed; another tradition is that when the Dakotas first came to the lake voices were heard, but they found no speakers; some think the word has changed its form.

Iyakhba,—sleepy ones; the name of the Iowa Indians and the country occupied by them. Early explorers state that this is the Sioux (Dakota) name. It is probable that 200 years ago the Santees pronounced this word as the Titons now pronounce it, Iyakhwa. As the kh is a sound not found in French it was often omitted, and usually expressed by h, if at all, which occasionally occurs. The spelling *Ayavois*, as given by Le Sueur, is as near to this word as could be expected.

Izuza (izuza),—whetstone; the Dakota name of Whetstone creek, a tributary of the Upper Minnesota; the Dakota form is retained on Nicollet's map.

Khakha,—falls; the Dakota name of St. Anthony's Falls, as pre-eminently *the falls*.

Khakha wakpa,—falls river; the Dakota name of the Mississippi river.

Kandiyohi (kandiyohi),—*kandi*, buffalo fish; *y*, euphonic; *ohi*, arrive in; name of the lake which still retains it, since given to the town and county.

Kanpeshka (kanpe ska),—name of a round, curved, white medal, made of shell and worn by the Dakotas, and probably given to the lake a little west of the boundary on account of suitable shells for making these ornaments which were found there.

Kaposia (kapozha, the *p* written by Dr. Riggs with a dot subscript to denote a peculiar palated modification),—light; the name of Little Crow's band, and the site of their village four miles below St. Paul on the opposite side of the river. The name was given in honor of their skill in the favorite game of *lacrosse*, in which one band played against one, or sometimes against two others, for large stakes. Success depended largely on swiftness (lightness).

Kasota (kasota),—clear or cleared off; the name sometimes applied by the Dakotas to the naked ridge or prairie plateau south of the village of that name, and now applied also to a creek running through it.

Mahtomedi (matomde),—*mato*, the gray bear, *ursus maritimus*, *mde* lake; the Dakota name of White Bear lake, now the name of a camp situated on it*.

Mahtowa: *mato* grizzly bear; *wau*, one; name of a station on Duluth Railway, north of Hinckley.

Mankato (makato),—the Dakota name of Blue Earth river, the name of the city as now spelled would in Dakota mean blue skunk (see remarks on pronunciation, *ante*).

Mayawakan (maya wakan),—*maya*, steep banks; *wakan*, wonderful, sacred, mysterious, here properly translated remarkable; the Dakota name of the Chippewa river, tributary to the Minnesota; the Dakota form is given on many old maps. It is said that *Chippewa* is our translation of the Dakota work Khakhatonwan, dwellers at the falls, *i. e.*, Falls of St. Mary, and that it was applied because the Dakotas sometimes spoke of it as the river down which they came.

Mdewakanton,—dwellers at the lake; a name applied to the part of the Santees occupying eastern Minnesota and western Wisconsin, said to have been given because they still continued for a time on lake Superior after the other Dakotas left it.

*A well-known summer resort, near the village of White Bear lake, near St. Paul.

Mdechan,—*mde* lake; *chan* wood, Wood lake; the Dakota name of the lake where General Sibley gained the decisive victory over the rebel Dakotas, Aug. 23, 1862.

Mdehdakinyan,—lake lying crosswise; the Dakota name of lake Traverse, it lying crosswise to Big Stone lake.

Mde Minnesota (mde minisota),—sky-tinted lake, or having water nearly clear, but with a slight whitish tint; the Dakota name of Clear lake near Fort Ridgely; the Dakota form is given on some old maps.

Mdeyata,—*mde*, lake; *ata*, at; at the lake; this expression was used by the Dakotas in speaking of lake Superior, regarded by them as pre-eminently *the lake*, and so not specially named.

Mde tanka, great lake, signifying the ocean, of which they retained distinct traditions.

Mdeyatanka,—*mde*, lake; *ya*, they speak, say; *tanka*, large; the lake spoken of as large; the Dakota name of Ottertail lake.

Mendota (mdote),—the mouth of a river; name of a village at the junction of the Minnesota and Mississippi. Those living at a distance usually spoke of it as Khakhamdote, junction with the Falls river, *i. e.* the Mississippi river.

Maka re ozey (maka khe oze),—yellow banks; the Dakota name of the Yellow Banks river, a tributary of the upper Minnesota.

Magha tanka,—big goose, *i. e.* swan; the Dakota name of Swan lake, Nicollet county.

Minneapolis,—*mini*, water; *polis*, Greek for city; how the *a* got in seems very uncertain, some regard it as merely euphonic, others as the Dakota prefixed preposition *a*, on, others as an abbreviation of the Dakota *kha*, falls, while still others, but I think with little plausibility, derive it from the Greek.

Minnehaha (minikhakha),—*mini*, water; *kha kha*, falls; khakha is derived from *kha*, curl, being the frequentative form used with *mini*, water, meaning falls; used with *i* mouth, meaning laughing. To translate Minnehaha, "laughing water," though not strictly accurate, is certainly an allowable poetical license; the name of the well known cascade near Fort Snelling; the Dakotas usually called it, chistina, small, in distinction from St. Anthony's falls.

Minneinneopa, or Mineopa, (mini inonpa), *mini*, water *inonpa*, second; the name of a beautiful cascade near Mankato, so called because the second of two falls near together.

Minneiska (mini ska),—*mini*, water; *ska*, white; the Dakota

name of the creek so called; as well said by Rev. A. L. Riggs "the i has no business there," yet it dates back to Nicollet's map.

Minneota (mini ota), — much water, a station on the Winona and St. Peter Railway, said to be so named by an early settler on account of an abundance of water flowing into his well.

Minneola, — *mini* water; *ola*, Latin diminutive, said to have been invented as a parody on Minneapolis, and applied to a township in Goodhue county, as the settlers thought its euphonious sound typical of the beauty of the country.

Mini wakan, — the wonderful water; the Dakota name of Devil's lake, said to have been applied on account of its being so large, and having no outlet. Wakan is persistently translated devil by many frontiersmen, but it is in no case used in that meaning. In names it is nearly always an adjective, meaning wonderful, remarkable; in other cases as an adjective, it means mysterious, sacred; as a noun it always means god.

Minnesota, — (mini sota), water nearly clear but slightly clouded, as that in the Minnesota river, so called by the Dakotas. This river is on old maps called St. Peter's, a name given by the French explorers.

Minnetonka (mini tanka), — great water; the name of the beautiful lake and summer resort near Minneapolis.

Minnewashta, — *minne*, water; *washte*, good; name of a lake known as "White Bear Lake," then "Lake Whipple," and since changed to Minniwashta, by act of the legislature, situated in Pope county, near Glenwood.

Okabena (hokahbena), — *hokah*, heron; *be*, nests; *na*, diminutive suffix; the nesting place of the herons; the name of the lake at Worthington.

Okaman (hokahman), — *hokah*, heron; *man*, nests; the name applied to mills near Lake Elysian, said to have been applied by the Dakotas to the same site. Man and be are variant forms of the same word. The loss of the h in these two words is accounted for by the lighter stress laid on this sound by Dakotas.

Okheyawabe, — *okhe*, hill; *yawabe*, referring to its being much visited; the Dakota name of Pilot Knob, back of Mendota.

Oiyuweghe, — the crossing; the name given by the Dakotas to Travers des Sioux, because they usually crossed the Minnesota here, in going from the upper to the lower villages.

Omaha, — the Dakota name of the Omaha Indians; applied to a small creeek in Southwestern Minnesota, on old maps.

Ojata (ozhate),—forks; the name of a station near Grand Forks.

Owatonna (Owotonna),—straight; the Dakota name of Straight river, on which the city of Owatonna is situated.

Pajutazee (pezhihutazi, abbreviated from Pezhihutazizi ka pi),—*peji*, generic name, including grasses and all other erect plants without wood stems; *huta*, root; *zi*, yellow; *kapi*, they dig; diggings of yellow plant root, or yellow medicine diggings; the Dakota name of the Yellow Medicine river, written by Nicollet Pejuta zizi; the name as first spelled was the name given by Dr. T. S. Williamson to his station, and is found in this form on a number of maps.

Ptansinta,—probably of *ptan*, otter, and *sinte*, tail; the name of the Dakota village at the head of lake Traverse.

Re ipa (khe ipa),—*Khe*, hill or ridge; *i*, prefixed preposition, to; *pa*, head; the Dakota name of the "head of the Coteau."

Remnicha (Khemnichan),—*Khe*, hill; *mni*, contraction of *mini*, water; *chan*, wood; the Dakota name of Red Wing, given on account of the union of these features there; applied also to Hay creek flowing into the Mississippi there.

Sappah (sapa),—black; the Dakota name of Black river, Wisconsin.

Shakopee (shakpi),—six; the Dakota chief of the band formerly occupying the site of this city was *Shakpidan*, Little Six. The usual Dakota name of the band was Tinta tonwan, Dwellers on the prairie.

Shunkasapa,—*shunka*, dog; *sapa*, black; Black Dog, a Dakota chief, and name of his village near Hamilton station, Omaha Railway.

Sisseton (sisin towanyan),—*sissin*, fish scales; *towanyan*, village; the most numerous clan of the Santee Dakotas. They occupied in common with the Wahpetons, nearly all Minnesota west of Carver, except the extreme northern part. The name was given them when they were further east, living principally on fish, and in one village.

Tamaha—pike; the Dakota name of Hudson; for legend see Neil's *Minnesota*, p. 94.

Tanpayukedan—*tanpa*, white birch; *yuke*, is there; *dan*, diminutive; the Dakota name of Birch Cooley, where our forces under Maj. Brown fought a disastrous battle in 1862.

Tchanshayapi, see Chanshayapi.

Tintah (Tinta),—prairie; a station on the Manitoba Railway.

Tintatonwan, see Shakopee.

Tipsinna,—a farinaceous bulbous root, a much used and highly prized article of food; the name applied to the Pomme de Terre, or apple river. The French is a translation from the Dakota, the English a mis-translation from the French.

Wahnatan (waanatan),—he who makes an attack; a celebrated Sisseton chief, formerly the name of a county in Minnesota.

Wabasha (Wapaha sha),—red battle-standard; as *wapaha* is also used to mean hat, this is sometimes incorrectly translated "Red Hat;" the name of the chief whose land occupied the country below lake Pepin and had their village on Winona prairie, which was for many years called "Wabashaw prairie" by steamboatmen and early settlers; it is now the name of a city and county, but the oft repeated statement that this was his residence is erroneous.

Wacouta (wakute),—he shoots; the name of the chief whose band was located at Red Wing; the name of the railway station next south of Red Wing.

Wahpeton (wakhpetonwan), *wakhpe*, leaves; *tonwan*, dwell, dwellers among the leaves, one of the four Santee clans; (see *Sisseton*), a town in Dakota.

Wahpekutey (wakhpekute),—leaf shooters, the smallest of the four Santee clans. They lived chiefly in the valleys of the Blue Earth and Cannon.

Wakinyan oye,—the thunderer's track; given by Nicollet who translated it lightning's track; the name of three small lakes near Big Stone lake. The Dakotas say that these tracks were made by the infant Thunder-god, probably the most worshiped of their deities.

Waraju,—*wagha*, cottonwood; *zhu*, pour, plant, etc.; the name applied by the Dakotas to the Cottonwood and Little Cottonwood rivers on account of the Cottonwood groves so frequent along them. The word *little* is, in Dakota, chistina, and placed after the noun.

Watonwan,—this word might mean "I see," or "he sees," intransitive; it may have been applied to this branch of the Blue Earth as being a prairie country and presenting a good prospect, but it is uncertain whether this is the meaning on which the appellation was given; the Dakota name of the river, now used for the county, also,

Waseca (wasecha),—rich, especially in provisions. I was informed in 1855 by a gentleman who was a stranger to me, who professed to be one of the first settlers, that this name was

given in response to inquiries as to the Indian word for fertile, and adopted as a name. In Dakota writing and books the word *waseca* is spelled as we spell the name, and is a word likely to be given in answer to such a question. The soil is also very fertile. I have since several times seen it stated in print that the word is a corruption of *washichun*, white man, given on account of a solitary white man residing there, but I am unable to ascertain that there was any such resident, or that any Dakota ever gave the place this name, and think the first derivation much more probable. It is the name of a city and county.

Wasioja (wazi ozhu),—*wazi*, pine; *ozhu*, place in, etc.; the Dakota name of the Zumbro river, given on account of the scattered pines; retained on old maps and applied by the whites to a village in Dodge county.

Wastedo,—*washte*, good; *do*, emphatic particle; name of a post office in Goodhue county.

Waubay (wabe),—place of hatching of birds; name of a lake and town west of Millbank, Dakota.

Wayzata (wazi yata),—*wazi*, north (also pine), *ata*, at; the name of the station at the north end of Lake Minnetonka.

Winona (winona),—first born if a daughter, diminutive of wino woman; the name of the city built on what was formerly called "Wabashaw's prairie." The name of the band was *Kiyuksan*, breakers in two, or violators, so called because they violated the custom forbidding relatives, however distant, to marry.

Yankton (ihanktonwan),—end village; the clan of Dakotas formerly occupying the southeast part of Dakota. It is said that this name was given when their village was at the west end of Lake Superior, but this is uncertain.

In preparing the above I am greatly indebted to an able article in *Iapi Oaye*, January, 1883, by Rev. A. L. Riggs, and to information obtained from my father, Dr. T. S. Williamson.

A. W. W.

XV.

ENTOMOLOGY.

BY O. W. OESTLUND.

MINNEAPOLIS, MINN., April 1, 1885.

Prof. N. H. Winchell, State geologist:

There is probably, at present, not a crop in this state more threatened and injured by insects than the cabbage. It is for this reason that I submit the following list and notes on insects injurious to the cabbage, as they were observed last summer on the experimental farm of the State University, incomplete as they may be when applied to the whole state, being the observations of but one season and confined to one county. Still, I hope they may have some value to the farmer and gardener in their endeavor to become familiar with and to overcome these pests; being the first record of several of these insects as occurring in Minnesota, they will also have their scientific value.

INSECTS INJURIOUS TO THE CABBAGE.

1.—*Pieris rapæ, Schrank—The white or imported cabbage butterfly.*

This is the most common and destructive of our cabbage insects. It was introduced from Europe, where it also proves quite destructive to the cabbage, about thirty years ago, and has already spread over the greater part of North America, proving that introduced species often flourish exceedingly, and become even more destructive than native species of similar habits. It has, apparently, already settled down for good in this state, and can be considered as a permanent addition to our insect-fauna. I believe that this species is so well known that no description

is necessary for its identification, but as we have several other species similar in habit and hardly less injurious, I shall give a short description of all of them, so that they can be more easily compared and identified by the intelligent farmer and gardener, who may wish to know something about the destroyers of their labor and how they may best free themselves from them.

Description.

The eggs.—These are laid by the white butterfly that we see hovering around our gardens as soon as the tender plants are ready to be set out in the spring, and are continued to be laid for successive broods during the whole season whenever the weather is at all favorable. They are very small; fusiform; ribbed longitudinally, which can be easily seen by a lens; of a light yellowish color, but which soon becomes darker. Generally they are found singly or only a few together on the under side, but also occasionally on the upper side, of the leaves.

The larvæ.—The larvæ, or worms, as they are more commonly called, are rather sluggish in their movements; of a velvety-green color, with black dots, a pale yellowish stripe down the back, and a row of yellow spots on each side. They are generally found in all sizes, from those just hatched to the full grown one, about one and a half inches in length. They are also found to feed upon the cauliflower, turnip, mustard, and other cruciferous plants, though they seem to be very partial to the cabbage.

The chrysalis.—The chrysalis is really an object of beauty and wonder, although we destroy it without consideration, as it proves so destructive to our garden if allowed to develop. It is about three-fourths of an inch long; angulated, and pointed at both ends; in color it varies with minute black dots from grayish-green to quite light. It is found suspended by a web of silk at the end of the body, into which the hooks of the posterior end are twisted, and also by a thread of silk, stretched around the back and fastened to the board, fence or stone under which the larva has chosen its place for transforming.

The imago.—The full developed butterfly has the body black and quite hairy; the wings white above, with a dusky or black space at the tip of the fore wings, and several black spots disposed in a line on the middle of the wings; on the under side the hind pair of wings are yellowish, the fore pair only so on the anterior part. It expands from two to two and a half inches.

Subject to parasites and sickness.

Several parasites are already known to occur in this country on the larvæ of this species, and they will probably prove an effective check on the too great increase in the future. As far as known, none have yet been observed in this state, but if not actually here they will be as sure to occur in due time as the butterfly itself. Parasites generally do spread a great deal slower than the insect on which they live. The larvæ are also known to be subject to some kind of sickness that occasionally carries them off in great numbers. During the past season this has proven to be very generally the case in this state. The cause of this sickness, or epidemic as it might well be called, has not yet been made out to satisfaction, but very probably it is, as has been suggested by some entomologists, some kind of fungus disease or rot, which is favored by the dampness of the weather and the slow vital energies of the larvæ during such times; for it has been observed that during long rains and continued dampness it is very prevalent among the larvæ, while during dry, or only showery, weather, it is rare. The larvæ as soon as affected cease to feed and become even more sluggish in their movements; their bodies become very pale and soft, and some time after they can be seen hanging from one of their legs, or fallen to the ground, and the contents of their body dissolved and running down as a black fluid, leaving only a black streak on the cabbage leaf as the remains of their former existence.

Preventives and remedies.

Whenever the insect can be destroyed in any of its stages it will prove an effective preventive, especially if it be the female. Generally we do not pay any attention to the chrysalids, even if we find them in great numbers on the fences, in the rubbish, etc., around our garden, but we let them all develop into the white butterfly, and this we allow to fly unmolested over our cabbage plants until they have been well stocked with the future brood; and not until the larvæ have become so numerous that they threaten to devour our whole crop, or at least seriously damage it, do we look around for some means of saving it. A great many remedies have been experimented on and proposed, but mostly they are either too costly or impracticable in their application to become of general use. When the crop is too

large to be taken care of by hand-picking, which is the cheapest and surest way in a small garden, we have found the application of hot water to be one of the best. It was tried several times last summer at the experimental farm of the State University, and with very satisfactory results. The thick leaves of the cabbage are such that they can stand water being sprinkled on them at a boiling point without any bad effect, and it will prove a sure destruction to all the larvæ. A good and careful cultivation is also very important. If we neglect our garden or field it will become only a too fit place for injurious insects, and remedies that we may apply will be of little use, while in a clean and well cultivated garden the injury will seldom become serious.

2.—*Plusia brassicæ, Riley.—The cabbage Plusia.*

This is one of the most destructive species to the cabbage in the southern states. It has been recorded as far north in the Mississippi valley as Illinois, but I think this is the first notice of its occurence in Minnesota. I have taken it repeatedly during the last season, both in Ramsey and Hennepin counties, where it by no means is a rare insect; and the extent of its injury is hardly less than that of the foregoing species. From present indications we have much to fear from it in the future. Few of our farmers and gardeners seem to be aware of its existence, but this is probably from the different habit that this species has from the foregoing and more common white cabbage butterfly. The imago, being a moth, is seldom ever noticed in the cabbage field, and the larvæ are in size and color somewhat similar to those of the white butterfly and can therefore be easily overlooked by the untrained observer. The food-plants of the larvæ in their native state are several of our wild herbs, but unfortunately they have also taken a liking to several of our garden plants, as the cabbage, turnip, tomato and celery.

Description.

The eggs.—According to Prof. Riley the eggs are pale, greenish-yellow in color, somewhat convex, and about .55 mm in diameter (.02 inch). From the centre radiate numerous elevated ridges which are divided by transverse and less distinct ridges. They are very loosely attached, either singly or in small clusters, to the leaves, for the most part to the upper, but exceptionally to the lower surface.

The larva.—The larva is light green in color, with several faint white lines along the back; thickest at the posterior end and somewhat tapering in front. It is one of the so-called loopers, and on being disturbed or in rest will raise the middle of the body so as to form a kind of loop and remain in this position sometimes for a long while. It eats long, irregular holes into the cabbage leaves. According to Prof. Riley the larvæ of this species are subject to several parasites and often to a fungus disease, and as they live exposed on the outside of the plant are often devoured in great numbers by birds. As far as my observations go with regard to these points in Minnesota, the larvæ were ordinarily found on the underside of the cabbage leaves, and of all the species I have observed as injurious to the cabbage, this one has been the healthiest and least exposed to parasites. I have raised several hundred of these larvæ and a very small per cent failed to reach maturity, and during cold and damp weather, when nearly every larva of the white butterfly was affected by disease, and even some of the other native species showed weakness, this species seemed to remain unaffected. This would lead us to infer that the species has lately extended its range into this state and has not yet been followed by its ordinary enemies, and finding here an uncontested field, increases without check. If this proves to be so we have much to fear for the coming years until the parasites will also have extended as far.

The pupa.—The pupa is about three-quarters of an inch long; dark brown in color. It can easily be seen through the very loose web-like cocoon that the larva spins around itself before undergoing the transformation. The place for transforming is generally on the leaf or stalk of the plant on which the larva has been feeding.

The imago.—The moth is of a grayish-black color, with a patch of silvery white on the fore pair of wings, and a spot of the same color immediately below this patch; the hind pair of wings are lighter colored, with posterior half blackish and surrounded by a fringe of white; the underside of the moth is of a dull silvery-gray.

Remedies.

This species has shown itself better able to withstand the application of insecticides than any other, and will therefore be

more difficult to get rid of. Hot water will kill the larvæ if it reaches them. We shall probably have to look to the natural enemies as the best check here as elsewhere, if they should prove to become as common as the white butterfly.

3.—*Plutella cruciferarum, Zell.*—*The cabbage Plutella.*

This little moth is very common over the greater part of the United States, and, like closely related species in Europe, proves very destructive to the cabbage, turnip, and similar plants. From the small size of the larva and moth of this species it seems to have been very generally overlooked in this country, and the mischief done by it ascribed to that of the common white butterfly. It has been found very common in Ramsey and Hennepin counties during the past season, and undoubtedly already exists over the whole state where cabbage is cultivated. Fortunately it only attacks the outer leaves, leaving the head uninjured; but it is incessantly at work on those, riddling them with small holes. And during very dry seasons, when they sometimes do multiply exceedingly, they may prove very destructive to the cabbage, and greatly stunt and retard the growth and the formation of the head.

Description.

The eggs.—Eggs were at several times noticed that very probably will prove to be those of this species. They were very small, oblong, about half or a little more than as broad as long; fastened from their side and not base as in those of the white butterfly; color white or whitish; surface very much wrinkled. Generally found singly, but often in clusters of two or more together or in a row.

The larva.—The larvæ are a little over a quarter of an inch long; cylindrical, gradually tapering from the middle towards both ends; color pale green; head and first segment commonly pale yellow. On being disturbed they have a very active wriggling motion, moving briskly backwards or letting themselves fall to the ground by a fine, web-like thread.

The pupa.—When about to pupate the larva spins for itself a very beautiful, gauze-like cocoon, through the wide meshes of which the pupa can plainly be seen, and can generally be found very plentiful on the outer leaves on which the larva feeds. The

pupa itself is about one-fourth of an inch long, of a white color, with the black eyes at the base of the antennæ very conspicuous.

The imago.—The moth measures about .30 in. in length to the tips of the closed wings, and when at rest the antennæ are directed in a straight line forward, and not turned backward as is generally the case. On being disturbed by walking through the cabbage field, it can be seen flying with a very quick motion, but only for a short distance, when it will again alight on some plant until disturbed.

Remedies applied to the other species are also generally very effective on this.

4.—*Ceramica picta, Harris.—The Zebra cabbage worm.*

Harris, some thirty years ago, called attention to this species as occasionally injurious to the cabbage, cauliflower, spinnach, beet, and other garden vegetables with succulent leaves. It has since, at several times, shown itself quite destructive to the cabbage, especially during dry seasons, when the wild plants, upon which it ordinarily lives, have become dried up. It was taken at several times on the cabbage during the last summer, in Minnesota, and must, therefore, be put down as one of our insect enemies to the cabbage against which we need to be on our guard. The larva is very conspicuous on account of the bright yellow markings, or bands, on either side. It lives, exposed, on the leaves of the plants on which it feeds.

Description.

The larva.—When young the larvæ are almost black. They are then gregarious in habit and can be found from twenty-five to fifty or more on a single leaf, but as they grow older they spread all over the field. When full grown they are about two inches in length, of a velvety black color, with the head, legs and under side tawny red; on each side there are two lateral yellow lines and bands, between which are numereus transverse, zebra-like lines, giving to the larva a very characteristic appearance.

The pupa.—The larvæ when full grown go into the ground and there change to the pupa, which is about three-fourths of an inch long, in color shining brown, and rather thickly punctured.

The imago.—The moth is nocturnal in habit, and therefore

seldom seen in the field. It is about the same size as the Plusia moth, but brown in color, shaded with purple-brown. It has three spots on each of the fore wings, edged with gray, and a transverse zigzag line, forming a more or less distinct W in the middle, near the outer margin. The hind wings are white, faintly edged with brown on the upper and outer edges.

On account of the larvæ when young having a gregarious habit, they can then be easily destroyed by cutting off the infested leaf and destroying it. The eggs are hatched in the early part of June, and the young colonies of larvæ should then be looked for.

5. — *Mamestra chenopodii, Albin. — The cabbage Mamestra.*

No injury has been reported or observed as caused by this species in the state, and so far only a few larvæ have been taken on the cabbage; but as it has shown itself very destructive to the cabbage in other parts of the country, it may, under favorable circumstances, become even as destructive here as elsewhere. The larva is easily distinguished from any of the foregoing by a lateral line along its body of pinkish color; the green color varies considerably, from a dark to a light green. The pupa is found in the ground, and the moth is of a yellowish-gray color, varying sometimes to a dark brownish gray. It has not got the silvery spots on the fore wings like those of the Plusia. In case the larvæ of this species should become very numerous and troublesome in this state, entomologists have recommended as the best remedy the use of poisoned turnip leaves as a trap. The leaves should be well covered with a London purple or Paris green solution and placed at intervals along the rows.

6. — *Murgantia histrionica, Hahn. — The harlequin cabbage-bug.*

During last summer some of the very characteristic eggs of this species were taken on the cabbage on the experimental farm of the University, giving indications of a new insect pest for the cabbage in this state. It is a southern insect, but has been known to extend its range northward from year to year, as the Colorado beetle extended its range eastward, though its progress has been a good deal slower. It has been recorded in the Mississippi valley as far north as Illinois, and Professor Lintner, in his first report as state entomologist of New York, intimates

that it is capable of extending its range as far north as to include Minnesota and Wisconsin. In the south it is one of the most destructive insects to the cabbage. It is not a larva or worm like the foregoing species we have noticed, but it belongs to the order Hemiptera, or true bugs, such as the plant lice, squash-bug, and similar ones, which are provided with a beak, or *rostrum*, as it is called, which they thrust into the plants on which they live and imbibe the sap, thereby injuring or killing the plant when they become very numerous. Although only the eggs have as yet been observed in this state, it is very probable that in the near future we shall have all the stages, and if it should prove to be as destructive here as further south we have another species that will not stand back to that of the white butterfly in the extent of its injury. I shall therefore call attention to it that our farmers and gardeners may be on the watch. As I have not had the opportunity to study this species in the different stages, having only seen the eggs, I shall give the description of Prof. Lintner, found in the report alluded to above. Any information or inquiry with regard to this species will be gladly received.

Description.

Eggs.—The eggs are beautiful objects, and are easily recognizable. They are cylindrical, with rounded extremities, placed on end, and cemented together by their sides. They are white, tinged with green, apically, with two black bands, the upper one of which is twice as broad as the lower, and placed a little nearer to the extremity of the egg. The apex is strikingly marked with a black crescent bordering the slightly-depressed lid (which opens upon a hinge for the escape of the larva), and occupying rather more than one-half of its circumference. The length of the egg is about one-half greater than its diameter, measuring .034 inch by .052 inch. They are arranged in two to four rows of three to six eggs in each row.

The larva.—The larvæ are small, pale-green, and when more advanced become orange-colored.

The pupa.—The pupa resembles the perfect insect in marking and coloring, but may be at once distinguished by having wing pads instead of wings, and is not capable of flight.

The imago.—Measures three-eighths of an inch in length by nearly one-fourth in width. It is conspicuously marked in shining blue-black, dull orange and white, as follows: The black

head has two short lines upon it of yellowish white; the thorax is orange, with a ring of black on each side, centered with a triangular orange spot, or with the black diminished and the ring either interrupted or broken into two spots. The coriaceous portions of the wing-covers are orange, crossed obliquely by two black bands, and their tips are black. The scutel (the large triangular piece covering the central portion of the body) is black, with a pale yellow spot at each anterior angle, a black terminal tip and a central cross of orange. Beneath, the joints of the abdomen bear upon their margin a row of triangular white spots, and intermediately there are three rows of parti-colored spots in orange and white.

No parasites are as yet known to prey upon this species, and it has been found very difficult to destroy by any ordinary application of insecticides.

7.—Aphis brassicæ, Linn.—The cabbage plant-louse.

The Aphidæ, or plant-lice, become at times the greatest torments to the gardener and agriculturist. There is hardly a plant that has not a species or more of this pest living upon it, and often great injury is done. The plant-lice belong to the order Hemiptera, or true bugs, and, like the foregoing species, are provided with a beak, which they thrust into the plant and suck the juices. The cabbage plant-louse has been found more or less common through the state, and is probably the most widespread species of those injurious to the cabbage. They are found in clusters or colonies on the upper side of the inner, or under side of the outer, leaves, but also sometimes solitary. The colonies are made up of wingless individuals of all sizes, and, further on in the season, also of winged individuals.

The young individuals are egg-shaped and of a dull, pale-green color, and their bodies dusted over with a pale-grayish powder. Antennæ and legs dusky black.

The females, or largest wingless individuals, are also coated with a gray, meal-like powder; egg-shaped and of a dull, yellowish-green color; eyes black, and also two large spots on the crown and one on each side of the neck; antennæ black, with the third joint yellowish. The nectaries, or honey-tubes, are short and black, as are the legs; base of the thighs pale-yellowish; body plump, large and unwieldy in its aspect, and about a tenth of an inch in length.

Winged individuals are dull-greenish in color, varying to pale dull-yellowish, and largely varied with black.

Remedies.

Fortunately this species has a great many enemies that ordinarily keep it within bounds, and it is only occasionally that they do multiply in such great numbers as to destroy or seriously damage a crop. Whenever a leaf is found affected it should be cut off and destroyed, so as to prevent, as much as possible, the spreading over the whole field. When very numerous, kerosene emulsion has been found very effective.

8.—*Haltica pubescens, Illiger.*

9.—*Crioceris striolata, Fab.*

The flea-beetles.

The little flea-beetles, as they are called on account of their jumping to an incredible hight on being disturbed, are very similar in habit and appearance to each other. They are found destructive, not only to the cabbage, but to most of our garden vegetables, by nibbling small holes into the leaves as soon as they come out of the ground, and continue to do so during the whole season. Often they so injure a bed of vegetables as to necessitate replanting. They are both very small, less than a tenth of an inch, and shining black; the second with a broad, wavy, buff-colored stripe on each side, and the feet reddish-yellow. The thighs of the hind pair of legs are very much thickened, like those of the grasshopper, giving them the great leaping power. They have been found very difficult to get rid of by any ordinary application of insecticides. Ashes sprinkled over the young plants will drive them off, to some extent. Frogs are known to destroy them in great numbers when found and allowed in gardens.

Other species will undoubtedly have to be added to this list in the future, as observations extend, but still we should hope not, as the cabbage-grower surely has sufficient with the evil as it at present appears.

Respectfully,

O. W. OESTLUND.

XVI.

THE CRYSTALLINE ROCKS OF THE NORTHWEST.*

I desire to call the attention of Section E to some of the interesting problems that beset the geologist who undertakes to study the crystalline rocks of the Northwest, and especially that part of the Northwest which is included in the state of Minnesota. Until very recently it has been the practice of geologists, almost without exception, to refer every crystalline rock in the Northwest either to the Huronian or to the Laurentian. Thus, when the survey of the state of Michigan was reinaugurated in 1869, the geologists of the upper peninsula were compelled to choose between a confession of their inability to establish the age of the rocks they were studying and the adoption of some of the recognized designations. In Wisconsin the case was similar, with the additional fact that the Michigan geologists were collaborators. The same was true again in Minnesota. What more natural than that the Michigan and Wisconsin rocks should be found to extend, with nearly the same features, into the state of Minnesota, and that their familiar names should at once be applied to them?

But when on more careful examination, both in the field and in the literature of the crystalline rocks, and over a wider extent of territory, and especially in the light of more recent researches in New England, New York, Pennsylvania, and Canada, it is found that the nomenclature is imperfect, and furnishes but a tottering scaffold to support the workmen of a great and ever-spreading structure, we are thrown into such difficulty and doubt that we are prone either to reject the old scaffold and build anew, or to clear away the accumulated rubbish about the foundation and examine on what basis the old one stands. To-day, however, we intend to do neither of these, but rather set forth a few of the incongruities and difficulties of the actual situation.

*Address of N. H. Winchell, Vice-President of Section E, at the Philadelphia meeting (1884) of the American Association for the Advancement of Science.

We are indebted, unquestionably, to the geologists of Michigan and Wisconsin for the most exhaustive and satisfactory description of the crystalline rocks of the Archæan age that has yet been published in America. In order that some of the difficulties of the situation may be made clear, I desire to review concisely the broad stratigraphic distinctions of the crystalline rocks that have lately been studied in Michigan, Wisconsin and Minnesota. By the aid of the published results of the surveys of Brooks, Wright, Irving, Rominger, Pumpelly, and others, a generalized statement can be formulated. To these I shall add such published results and unpublished field observations from Minnesota as may be furnished by the survey of that state, in order that the scheme may cover correctly the crystalline rocks of the entire Northwest.

Omitting the igneous rocks, which in the form of dykes cut through the shales and sandstones of the Cupriferous formation, and are interbedded with them in the form of overflows, we may concisely arrange the crystalline rocks, disregarding minor differences and collating only the broad stratigraphic distinctions, in the following manner, in descending order:

There are six groups:

First group.

Granite and gneiss with gabbro.—This group is represented in Minnesota by the gabbro and red syenite at Duluth, and by the extension of this range of hills northeastwardly nearly to the international boundary. Its thickness is unknown, but certainly reaches several hundred feet. The outcrop of red granite near New Ulm, lying under the conglomerate and red quartzyte, is probably in the southwestward line of extension of this group. This group is represented by No. XX southwest of lake Michigamme, by No. XX at Menominee and by No. 1 and 1a at Black river.

Second group.

Mica schist.—This group consists of schists that are micaceous and often staurolitic as well as garnetiferous. It can be seen in Minnesota on the Mississippi river at Little Falls, and at Pike rapids. The schists are variously associated with beds and veins of granite and gneiss. This is No. XIX at Marquette, XVII to XIX

at Menominee, XX to XXII at Penokee, and has a maximum thickness of 5,000 feet.

Third group.

Carbonaceous and arenaceous black slates, and black mica-schists.—These sometimes pass into roofing slates, with beds of iron ore, quartzyte and dioryte. This group includes the black slates of the Animikie group in northern Minnesota, of Knife lake and Knife portage on the St. Louis river, and carbonaceous slates lately reported near Aitkin on the Mississippi river. It includes Nos. XIV to XVII at Marquette, Nos. VI to XVII at Penokee, and Nos. XV and XVI at Menominee. Thickness 2,600 feet.

Fourth group.

Hydro-mica and magnesian schists.—Soft and obscure, becoming quartzose and also hæmatitic, also with numerous beds of dioryte. In Minnesota this is the iron-bearing horizon at Vermilion lake. It is Nos. VI to XIV at Marquette, Nos. IV to VI at Penokee, and Nos. VI to XI at Menominee. Maximum thickness 4,450 feet.

Fifth group.

This is the group of *gray quartzyte and marble.* It is represented by No. V at Marquette, Nos. II to V at Menominee and Nos. I to III at Penokee. In Minnesota this horizon seems to run along the south side of Ogishke Muncie lake, near the international boundary and includes perhaps the great slate-conglomerate which is there represented. Normal thickness from 400 to 1,000 feet; but if the great conglomerate of Ogishke Muncie be included here, the thickness of this group in northern Minnesota will exceed 6,000 feet.

Sixth group.

Granite and syenite with hornblendic schists.—This lowest recognized horizon has frequently been styled Laurentian. In Minnesota it is found on the international boundary at Saganaga lake, and large boulders from it are included in the overlying conglomerate at Ogishke Muncie lake, showing an important break in the stratigraphy. Thickness unknown but very great.

These six great groups compose, so far as can be stated now, the crystalline rocks of the Northwest. Their geographic relations to the non-crystalline rocks, if not their stratigraphic, have been so well ascertained, that it can be stated confidently that they are all older than the Cupriferous series of lake Superior, and hence do not consist of nor include metamorphosed sediments of Silurian or any later age.[1]

This statement of the grand grouping of the crystalline terranes of the Northwest may be varied by the addition of detailed and minor distinctions and by subdivisions, but its correctness rests upon careful observations and reports of competent geologists, and cannot at present be gainsaid.

Examining these groups more closely we find:

I. We have beneath the red tilted shales and sandstones, a great *granite and gabbro group.* This has been variously regarded by different geologists. While by many early observers it was classed as older than the series which has latterly been designated Huronian, and by others styled igneous and local, it has by Brooks been placed with that series and denominated "the youngest" of the Huronian strata, though no such rocks had ever before been mentioned as pertaining to the Huronian. By Irving it has been made the base of his Kewenawan. By Hunt it has been parallelized with the Montalban. It includes, in my opinion, the felsytes and porphyries which have been styled Arvonian, and it is very certain that in many places it has passed for typical Laurentian. The gabbro is very generally admitted to be of eruptive origin, and in its great development in Canada it was once styled Upper Laurentian, and later was known as Norian. While the gabbro is certainly eruptive, the associated granite and gneiss exhibit evidences of being metamorphic in their nature. In northern Minnesota this horizon of granite is characterized by a red color and it has an aggregate chemical composition almost identical with that of some of the associated felsytes. The magnetite of the gabbro is often highly titaniferous and so abundant that the rock has attracted attention as an iron ore. The gabbro does not always appear where the granite is present, but extensive areas of granite are spread out without any sign of variation, interruption or alternation with the gabbro. In other places these two rocks are intricately and intimately mingled both horizontally and perpendicularly; but the gabbro may be considered in

[1] The term Silurian here is understood to cover nothing below the base of the Trenton.

general as the underlying formation. Both these rocks seem to have been molten, and simultaneously so, in some places; but in the great mass of the red, granitic rock, there is a gneissic structure, and in its finely crystalline state, when it seems to vary to felsyte, it exhibits a laminated structure which is evidently due originally to sedimentation. Along these laminations, and coincident with them, is a finely lined striation which exhibits the "streamed" structure, sometimes appealed to, to show the igneous nature and origin of the rock. These felsytes are occasionally arenaceous, with irregularly rounded or subangular quartz grains, and sometimes are porphyritic with quartz and orthoclase. Veins of red granite intersect the gabbro, and the gabbro surrounds isolated masses of the granite. Transported, boulder-like masses of both are found embraced in a common paste among the later igneous outflows of the Cupriferous, where their existence is as great a puzzle as that of pebbles of red felsyte and quartz-porphyry in the red conglomerates. This red granite, so far as I have observed, generally consists largely of orthoclase, and in several instances passes imperceptibly into red felsyte. It contains also quartz and hornblende, the latter generally changed by decay. The gabbro, when unaffected by proximity to the red rock, consists of the three essential ingredients: labradorite, diallage and magnetite, with some necessary products of alteration, but in the vicinity of contact with the red rock it also holds orthoclase and quartz.

II. Below this granite and gabbro group is a series of strata that may be designated by the general term *mica schist group*. This is the principal, but not the only, horizon in which mica schist exists. This division is penetrated by veins and masses of red biotite-granite, which appear to be intrusive in somewhat the same manner as the red granite in the gabbro overlying. However, whether this granite is exotic, or can be referred to aqueo-igneous fusion and transmission of the sedimentaries in a plastic state through fissures in the adjacent formations, is a question which still is a matter of earnest investigation. The existence of the great associated igneous gabbro is suggestive, if not demonstrative, of the presence of an adequate agent for such a metamorphism — unless it be claimed, indeed, that such an extravasation of molten rock could take place without any marked and traceable effect on the contiguous formations. These granite veins penetrate only through the overlying gabbro and this underlying mica schist. They are wanting or comparatively

rare throughout the rest of the crystalline rocks. On the other hand there is an abundance of diabase and other doleritic rock, in the form of dykes, throughout all the crystalline strata. This points to the mere local nature of the origination of these granitic veins, and hence to the metamorphic nature of the granitic mass with which they are connected. It has been shown by Dana that granite suffers a change to mica schist, in western Massachusetts; Brooks, as well as Emmons, has shown it interstratified with limestone in St. Lawrence county, New York. They both also state that the Potsdam sandstone becomes gneissic. The same has been affirmed in Vermont by Dr. Hitchcock, and by Dr. Frazer in Pennsylvania. Hence, there is no impropriety in supposing that some great change has passed over the sedimentary strata of this horizon throughout a wide extent of country reaching from the Atlantic to lake Superior, and that in the emergences of upheaval and dislocation the sediments of one formation were enabled to penetrate transversely into the strata of another.

This mica schist formation has an aggregate thickness of about 5,000 feet, and sometimes is hornblendic rather than micaceous.

III. The next lower grand division, which is the third, might be styled the *black mica slate group*. This group contains much carbon, causing it to take the form of graphitic schists, in which the carbon sometimes amounts to over forty per cent.[2] These schists are frequently quartzose, and also ferruginous, even composing valuable ore deposits, as at the Commonwealth mine in Wisconsin. Associated with these black mica slates, which often appear also as dark clay slates, are actinolitic schists, the whole being, in some places, interstratified with dioryte. Their estimated thickness is 2,600 feet.

IV. Underneath this is a very thick series of obscure, *hydromicaceous and greenish magnesian schists*, in which, along with beds of gray quartzyte, and clay slates, occur the most important deposits of hæmatitic iron ore. The lower portion of this series, which at Marquette is represented rather by hornblende and chloritic quartz schists, and more rarely is mined as a magnetic quartz schist, at Penokee is known as "the magnetic belt." This division of the crystalline rocks has numerous heavy beds of dioryte.

V. Below this series of soft schists, which terminate downward

[2] A recent analysis of a specimen from near Aitkin, Minnesota, showed between forty-two and forty-three per cent of carbon.

with the magnetic iron ores, is the great *quartzyte and marble group*. The marble lies above the quartzyte, and in the Menominee region has a minimum thickness of at least one thousand feet; while at Marquette it graduates into a dolomitic quartzyte of indefinite extent, the whole group there being essentially a quartzyte. This is a most persistent and well-marked horizon. The quartzyte sometimes holds feldspar; thus having an appearance of granulite. In northern Minnesota, the great slate-conglomerate of Ogishke Muncie lake seems to represent the lower portion of the great quartzyte of this group, and to be the equivalent of the lower slate-conglomerate of the "typical Huronian," in Canada. In both places this conglomerate is sometimes speckled with masses of red jasper. The marble of this group appears adjacent to the conglomerate south of Ogishke Muncie lake, and in such a position as to overlie it, exposing a thickness of at least twenty-two feet.

Now, the difficulties of the situation arise when we cast about to find names for these parts. What are the eastern representatives of these western groups, and by what designations shall they be known?

Since the geological survey of New York, and the publication of its final report, the progress of geological science in Europe and America has rendered it necessary to revise some of the dogmas which were regarded as fundamental by the New York geologists, and to reject entirely some others. Among these may be mentioned the then current theory that the term "primary" should be applied to any massively crystalline rock, and that all such rocks belong to the bottom of the chronological scale of geology. If the apparent structural relations of the formations, as seen in the field, did not agree with this theory, some violent movement in the earth's crust was at once conjectured so as to bring nature into accordance with the true theory. Latterly, however, it has been shown abundantly by Dana and others, that the Trenton, Hudson river and other Silurian rocks are converted into crystalline schists; by Whitney that the Tertiary rocks become crystalline; by Brooks and Frazer that the Potsdam sandstone becomes gneissic; by Reusch that the clay slates, interbedded with the granites and gneisses of the Bergen peninsula of Norway,[8] contain characteristic Upper Silurian fossils, and by Hitchcock that the Helderberg rocks of New York are involved in the crystalline terranes of New Hampshire.

[8] Lesley, Report C4.

These more recent crystalline series, however, may all be considered as excluded from the scope of search for any parallels to the crystalline groups of the Northwest. Our inquiry will involve only the well-known names Laurentian, Huronian, Taconic, Montalban, Arvonian, Norian.

We meet at the outset with the question which has now become as historic in American geology as the Cambro-Silurian controversy in England, and which concerns very nearly the same geological horizon, viz.: Is there a formation such as claimed by Emmons — the Taconic? On this geologists are yet divided. We conceive, however, that the division is caused, not so much by doubt as to the existence of a sedimentary fossiliferous formation below the New York system, and separating it from the "primary," as by doubt as to which and how many of these sub-Silurian strata are to be included in the designation of Taconic. Having now, however, given the subject very careful consideration, I am ready to state my very positive conviction that Dr. Emmons was essentially right, and that the Taconic group will have to be recognized by geologists and adopted in the literature of American geology.

Dr. Emmons, in 1842, issued the first that appeared of the volumes of the final report of the New York survey. In that volume he formally sets forth the Taconic system, although, as he admits, in an imperfect manner, the area in which the rocks exist not being in his (the second) district. In this first presentation of the system he extended it geographically too far east, and unfortunately chose a name for it which is appropriate only to a part of that eastward extension. We are indebted to the researches of several volunteer geologists, Wing, Dana, Dale, Dwight, for the disentanglement of the overlying Hudson river rocks from the true Taconic rocks, and the demonstration of the incorrectness of Dr. Emmons' eastward extension of his system in southern Vermont. Dr. Emmons' claim, however, in all its essential points, remains intact. This consists in the existence of a series of sedimentary deposits, largely metamorphic, below the Potsdam sandstone, and separating the Postdam from the crystalline rocks known as "primary," in an orderly chronological scheme.

In his report on the agriculture of New York, issued four years after that on the geology of the second district, he makes more definite and convincing statements, going over the whole subject *de novo*. He gives diagrams showing the Taconic slates lying below the Calciferous sandrock unconformably, at White-

hall in Washington county, a region that had been colored by Mather and Hall on their geological maps as Hudson River, and lying in the general area described by Emmons as Taconic. He gives one also from the hills of Greenbush, opposite Albany, not far from the locality in which Mr. Ford has since discovered primordial fossils, where he also shows the Calciferous lying unconformably upon the Taconic, the former being fossiliferous. He also describes the Hudson River slates as lying unconformably on the Taconic, a fact which cannot be called in question since the recent discoveries of Wing, Dale and Dwight, and the stratigraphic investigations of Dana. In fact, the investigations of these geologists, instead of destroying the Taconic system, are only confirmatory of the published statements of Dr. Emmons in 1846.

Although the existence of the Taconic in Maine and Rhode Island, as claimed by Dr. Emmons, may not be maintained by further research, it is certain that he had the approval of Dr. Douglas Houghton in extending it into the state of Michigan. In later years, he also traced these rocks through Pennsylvania and Virginia into North Carolina. In Michigan his identifications have since been set aside and the same rocks have been denominated Huronian by Brooks, Wright, Irving and others. In North Carolina Mr. Kerr has, in the same way, substituted the name Huronian. The conclusive fact that these slates had been seen by Dr. Houghton, in many localities, to pass beneath the Potsdam sandstone, was considered ample to supply the only important point of evidence lacking in the Hudson valley. Dr. Emmons closes his discussion by stating his theme thus, referring to the facts obtained from Dr. Houghton: "It would be difficult to add to the weight of this testimony in regard to the separate and independent existence of a system of fossiliferous rocks, of an age anterior to the Silurian or New York system."

It is not necessary to refer to the controversies that arose from the creation of the imaginary Quebec group, nor to characterize in deserved terms the attempt to bury the Taconic in the Quebec coffin. It is not necessary to quote the support which Emmons had from Barrande, nor to recount the discoveries of Mr. Ford, nor the observations of Brooks in St. Lawrence county, N. Y., and Rogers in Pennsylvania, though these last both affirm that beneath the Potsdam sandstone are extensive beds of semi-crystalline strata.[4]

[4] Address of H. D. Rogers, 1844, before the Assoc. Amer. Geol. and Nat.

There may be reasons why the current literature of American geology is almost silent respecting the great work of Emmons, and why the Taconic is not known among the recognized geological formations; but we have nothing to do with these at this time. We have to say now only that it seems necessary to admit that when Dr. Emmons insisted on a great group of strata belonging to the age of the Lower Cambrian, lying below the Potsdam sandrock in New York, he had some foundation more substantial than imagination or mere hypothesis. He may have chosen an unfortunate designation, he may have but imperfectly understood the extent and importance of his discovery, and he may have incorrectly described its range and scope, but none of these faults, nor all of them, should deprive him of the credit of having made the discovery. He did more, he defended it to the last day of his life, and averred that "the Taconic system stands out as boldly as the Carboniferous."[5] The argument against the Taconic system, which appeals to imperfect or incorrect definition by its author, will apply with equal force against the Silurian system and also against the Cambrian; also against the Huronian and Laurentian, and perhaps with still greater force against the Hudson River, since none of these were correctly and properly defined at first by their authors.

If the equities of geological nomenclature, in the light of the results of later researches, demand of geologists of this generation a fair consideration of the claims of Dr. Emmons, that consideration must be granted. No amount of error, though heaped to the sky and supported by the highest authority, can long subsist. The truth, though tardy in asserting itself, will finally throw off the burdens under which it has labored, and will shine the brighter for the darkness which preceded it.

If we examine the descriptions, given by Dr. Emmons, of his Taconic system, we shall find that he makes the following broad stratigraphic distinctions:

I. His highest member is what he designates *black slate*, which he declares, in some cases, plunges apparently beneath the "ancient gneisses" and contains a considerable amount of carbonaceous matter. In this slate, at Bald mountain, were found two genera of primordial trilobites that were described by Dr. Emmons, the much buffeted *Atops trilineatus*[6] and *Elliptocephala asaphoides.*

[5] Letter to Jules Marcou, dated Raleigh, N. C., Nov. 6, 1860.

[6] According to Mr. Ford this is *Conochoryphe.*

II. Under the black slate his next grand distinction was the so-called *Taconic slate*, which he described as argillaceous, siliceous and "talcose," the upper part being suitable for roofing and other portions adapted for flagging. It is greenish, grayish and sometimes of a chocolate color. Its grain is very fine, but in some places it is arenaceous rather than argillaceous. Thickness about 2,000 feet.

III. Below this great mass of soft schists, he described, in the first place, a mass of 500 feet of limestone, designated "Stockbridge limestone," which graduates downward into "talcose" or magnesian sandstones and slates, the whole having a thickness of about 1,700 feet.

IV. Under this limestone is his "granular quartz-rock," more or less interstratified with slates, and becoming, in some places, an immense conglomerate with a "chloritic paste." In this conglomerate are fragments of the underlying gneiss, or

V. A formation which constituted, in his scheme, the "ancient gneiss" on which the Taconic system was said to lie unconformably.

Now it requires but a glance to perceive how closely this order coincides with that which has been independently and laboriously worked out in the Northwest. We have in both instances a "black slate" which in one case is said to be at the top of the system, but to pass apparently beneath the "ancient gneisses," and in the other is reported to be overlain by a group of mica schist and the "youngest Huronian," a mass of gneiss and gabbro. Below the black slate in both cases is an immense series of soft, hydro-mica and magnesian schists. These again are followed by limestone which in the Northwest often forms marble, and in New England sustains extensive marble quarries. This has various transitions to slate and to a hard sandrock, but in both places it becomes known, in its lower portions, as a great bed of quartzyte; and finally at the base is coarsely conglomeritic with masses of rock from the great underlying series of gneiss. Were there no other precedent this very parallelism would be taken at once as demonstrative, or at least indicative, of equivalence of age. The "Stockbridge limestone," however, at Stockbridge, seems to be of the Trenton age, according to Professor Dana; and where it appears in the Taconic mountains, further south and west, it is assumed by him to be of the same formation. But no one can affirm safely that the Taconic range of mountains is made up of the Trenton and Hudson River for-

mations till the crucial test has been applied to them successfully in the discovery of the characteristic fossils, and assuredly not, in the absences of this test, in the face of the foregoing parallelism with a limestone known to lie much lower; and in the face of the discovery of primordial fossils in Bald mountain some miles further north in Washington county, New York. It is to be remembered also that the schists of Mt. Washington are distinctly different from those of southern Vermont containing the Trenton fossils found by Mr. Wing, "a change" taking place in them not far south from the point at which the fossils were found, continuing thence to the southern extremity of Mt. Washington.[7]

Now, however, we are confronted with another difficulty. The geologists of Michigan and Wisconsin have set aside Dr. Emmons' identification of the Menominee rocks with the Taconic in 1846, and have called them Huronian, the same that has been done in North Carolina by Mr. Kerr, parallelizing them with the Canadian system, which in 1855 was so named by Dr. T. Sterry Hunt.[8]

It becomes necessary, therefore, to ascertain of what the Huronian consists. Dr. Hunt sets out with the statement that it was designed to include the younger and unconformable series of metamorphic rocks found on the shore of lake Huron and in the valley of the Thessalon river, "and also the so-called volcanic formations of lake Superior." Thus the avowed intent was the same as that of Dr. Emmons in erecting the Taconic system. If we seek for the actual stratigraphic and mineralogical characters of these rocks, we shall find them in the geological reports of the Canadian survey, particularly that of 1863.

In descending order the original Huronian consists of the following strata, disregarding the diorytes and other "greenstones," all of which are thought by Logan to be of igneous origin, though included in the thicknesses given.

White quartzyte	400 feet.
Limestone	200 "
White quartzyte	1500 "
Limestone, siliceous and cherty	400 "
White quartzyte	2970 "
Red jasper conglomerate	2150 "
Red quartzyte or conglomerate	2300 "

[7] Dana, *Amer. Jour. Sci.* (3) XVII, 376.

[8] Equisse geologique du Canada; Azoic rocks, Rep. E, p. 72.

Slate conglomerate	3000 "
Limestone	300 "
Slate conglomerate	1280 "
White quartzyte	1000 "
Chloritic and epidotic slates	2000 "
Gray quartzyte	500 "
Total	18000 "

Of this series of 18,000 feet, 900 feet consist of limestone; 2,000 feet consist of "chloritic and epidotic slates," and 15,100 feet consist of quartzyte and conglomerate. Perhaps 5,000 feet of this last thickness may be considered intrusive, consisting of dioryte and other forms of "greenstone." This will leave 10,000 feet, at least, for the aggregate thickness of quartzyte and conglomerate, being nearly double that observed in the same horizon in northern Minnesota.

It is plain to see that if there be any parallelism between these beds and the various groups made out in the Northwest, the whole of these strata must be made the equivalent of group v, or the *quartzyte and marble group*. The 2,000 feet of chloritic and epidotic slates, represented as near the base of the original Huronian, followed as they are by an immense thickness of conglomerate and slate conglomerate, are anomalous unless there be below them other slate conglomerates. This, indeed, is very probable, since, on the shore of lake Superior, near the mouth of the river Doré, according to the same authority, the lowest part of the Huronian is seen to consist of a green slaty conglomerate, containing "boulders" of granite and gneiss.

The extension of the term Huronian from the horizon of the original Huronian, upward through the overlying groups, may be justified by the expression of the original intent in the application of the term, but it certainly does not seem warranted by any description of rocks by the Canadian geologists, nor by any claim that usually has been put forth by the authors of the name.

There is, therefore, a conflict between the Taconic and the Huronian, both in respect to the horizon which they are intended to cover (both being referred by their authors to the Lower Cambrian) and in the horizon of rocks which they actually compass. The Huronian, however, in its original and typical description, can be parallelized with only the very lowest of the strata that were included in the typical and original Taconic; while the Taconic stretches upward at least as far as to include

the fourth and third grand groups made out in the Northwest, that is to say, the *hydro-mica and magnesian schists*, and the *carbonaceous and arenaceous black slates.*

This leaves two series of rocks untouched by the scope of either the Huronian or the Taconic, as these systems were at first defined, namely: the *mica schist group* and the *granite and gneiss with gabbro group.* In the term *Montalban* proposed for these groups by Dr. Hunt, the two are united and the constant distinctness which they seem to maintain is not recognized. The granite and gabbro group has affinities with the overlying *Cupriferous rocks*, and perhaps, as Irving has suggested, should be considered the base of that series which Brooks has named "Keweenawian," whereas the mica schist group has affinities with the underlying groups, and has, without exception, been assigned to the same system and age as those underlying groups. The granite and gabbro group has likewise been designated differently.' The gabbro, being an igneous rock, varies much in its prevalence and in its apparent relation to the granite. Its greatest development produces in Minnesota a range of low hills which extend northeastward from Duluth. Under similar circumstances, this group has received the name *Norian*, though at first called *Labradorian*, and thought to be a part of the Laurentian.[9] The granite and gneiss, also, associated with the gabbro, have received, under one of their modified conditions, the special designation *Arvonian*, on the supposition that these rocks where they so appear, are not modified conditions of granite and gneiss, but represent independent strata that lie near the bottom of the "Huronian," equal in rank to any of the other groups. I think I have shown elsewhere[10] that the Arvonian rocks of lake Superior are interstratified with the Cupriferous, and also that they are modified sediments of the Cupriferous. Instead of being near the bottom of the "Huronian" in the Northwest, they overlie all the other groups that have been assigned to the Huronian by Irving, and constitute a part of the great series of "younger gneisses" which by Brooks has been ranked as the "youngest Huronian."

The interesting variety of nomenclature, as brought out by the foregoing remarks, can be seen by a glance at the accompanying tabular arrangement, where the various parallelisms and the conflicting nomenclature are placed in adjoining columns.

It is evident from this table that at present it is a hazardous,

[9] It was described by Emmons under the term "Hypersthene rock."

[10] A. A. A. S. Cincinnati meeting; Minnesota Survey Rep. for 1880, p. 36; *ibid*, 1881, p. 110.

and perhaps an impossible, undertaking to assign the groups of the crystalline rocks of the Northwest to any of the terranes that have been named further east, without violating somebody's system of nomenclature. Some of the ground has been covered several times by different names, but on different hypotheses of structure, origin and parallelism. Respecting the horizon known as "Laurentian," there is an approach to unanimity and agreement. This, however, consists more in a tacit consent to style the lowest known rocks Laurentian, than in any agreement among geologists as to the nature and composition of the strata. The Taconic of Emmons, which has been buffeted and combated from the day of its birth, has from that very circumstance been generally ignored by geologists, because of a certain air of dubious authenticity which accompanies the word. The term Huronian has been allowed to stand and to flourish, partly because of the high authority on which it rests and the remoteness and inaccessibility of the typical locality, and partly, at first, because of the non-publication of Dr. Emmons' protestation that it was the equivalent of some part of his Taconic, and later, because, after Emmons' death, as well as before, his opponents were active in spreading views adverse to the Taconic system throughout the literature of American geology. The original Huronian has grown from the dimensions of a single group (the quartzyte and marble group), so as to include all the crystalline rocks lying above that group, spreading from the Laurentian to the unchanged sediments of the Upper Cambrian. This has become so obviously wrong, in some cases, and has included groups of rocks so plainly extra-Huronian, that a double and triple nomenclature has been applied to a part of these upper rocks, for the purpose of relieving the term of the heterogeneous burden which it was otherwise compelled to carry. These new names, with the exception of Montalban, seem to be of value only as regional designations, the strata which they represent being igneous or metamorphic, and hence liable to be wanting in some places and to be non-crystalline in others. They further complicate the stratigraphic nomenclature, since the strata are probably only the locally modified parts of the same system. Their geographic distribution in the Northwest not only indicates their stratigraphic horizon, but also their limited and local existence.

In conclusion, the chief points brought out in this discussion may be stated more concisely:

1. The crystalline rocks of the Northwest are comprised under six well-marked comprehensive groups.

2. The Taconic of Emmons, so named in 1842, and more correctly defined in 1846, included three of these groups.

3. The Huronian of Canada is the equivalent of the lowest of the Taconic groups, and the perfect parallel of only the lowest of the groups in the Northwest that have been designated Huronian.

4. The uppermost of the groups in the Northwest is local in its existence and exceptional in its character, and has received, therefore, a variety of names.

5. There are, therefore, confusion and conflict of authority in the application of names to the crystalline rocks of the Northwest.

GROUPS.	EMMONS.	HUNT.	BROOKS.	IRVING.	EQUIVALENTS IN MICHIGAN.	EQUIVALENTS IN WISCONSIN.	EQUIVALENTS IN MINNESOTA.
GROUP I. Granite and Syenite with Gabbro.	Hypersthene Rock. (Regarded as part of the primary.)	Labradorian. Norian. Upper Laurentian. Arvonian.	Youngest Huronian.	Base of the Keweenawan.	XX.	I and Ia at Black river.	Duluth. Brule Mountain. Misquah hills. Beaver Bay
GROUP II. Mica Schist.					XIX at Marquette. XVII-XIX at Menominee.	XX-XXII at Penokee.	Little Falls. Pike Rapids. Outlet of Vermilion lake.
GROUP III. Carbonaceous and Arenaceous Black Slate.	Black Slate.	Animikie.	The Huronian of Brooks. 1873.	The Huronian of Irving. 1879.	XIV-XVII at Marquette. XV and XVI at Menominee.	VI-XVI at Penokee.	Animikie Black Slates. Grand Portage.
GROUP IV. Hydromica and Magnesian Slate.	Taconic Slate.				VI-XIV at Marquette. VI-XI at Menominee.	IV-VI at Penokee.	At "The Mission" Vermilion lake. Vermilion Iron Mines.
GROUP V. Quartzyte and Marble	Stockbridge Marble. Granular Quartz Rock.	The Huronian of Canada, 1855.			V at Marquette. II-V at Menominee.	I-III at Penokee.	Ogishke-Muncie lake.
GROUP VI. Granite and Gneiss with Hornblendic Gneiss.	Primary.	Laurentian.	Laurentian.	Laurentian.	Laurentian.	Laurentian.	Laurentian.

Montalban. Taconic System. 1842-1846.

XVII.

GEOLOGICAL NOTES IN BLUE EARTH COUNTY.

BY PROF. A. F. BECHDOLT.

Interglacial peat.— Some time ago Mr. Z. Harrington, of Mankato, showed me a section, a foot long, four inches wide and three inches thick, composed of organic matter, mainly compacted leaves, sedges, etc., and resembling a poor lignite or compressed peat. When first seen it was yet moist, and could be cut like hard soap. The layers, of which it is composed, were also somewhat elastic. On drying it became harder, more brittle, and cut like wood. On Saturday, October 18th, I visited the place, in company with Dr. Harrington, where it is found. This is in Mankato township on the land of Messrs. Pleasanton and Powell, in the bluff of a ravine bearing a stream that flows into the Le Sueur river from the north. This organic deposit is seen in both banks of the ravine, and can easily be traced horizontally about three hundred feet, and then is lost. It has a pretty uniform thickness of about two feet, is overlaid by about six feet of dark drab clay containing some pebbles of quartz, limestone and shale, and disseminated rolled fragments of lignite. This clay effervesces briskly in hydrochloric acid. A similar clay lies under this organic mass, considerably thicker than the upper clay. A short distance further down, into the deeper parts of the ravine, brings to the surface glacial boulders. This seems to me, therefore, to be a mass of organic matter collected in a low place in the glacial clay surface some time during the glacial period, probably toward the close. A fragment is sent with this as a specimen. The rootlets of living plants traceable in this specimen disappear further in the bank when the surface is cut away a few feet.

[NOTE.—This interesting observation of Prof. Bechdolt shows the wide extent of the peat deposit, which accumulated between

two epochs of glacial cold, in southern Minnesota. In eastern Freeborn and in Mower counties it has been found extended over an area of several townships, lying outside of the morainic belt that crosses this part of the state north and south, and yet separating two distinct glacial clay deposits.* In Blue Earth county it is here found on the opposite side of the same morainic belt, and within the area of the glacial activity of the last cold period. If the deposits at these two points were contemporaneous, it is necessary to find some explanation of the extension of till eastward, so as to cover it several miles beyond the supposed farthest limit of the moving ice, in Freeborn and Mower counties, and of the preservation of it from disruption by the ice in Blue Earth county while it prevailed over a great area, and extended into Iowa, as well as of its final burial beneath the six feet of pebbly clay which lies over it. If the deposits at those two points were not contemporaneous, but one succeeded the other by an interval of time amounting perhaps to several thousands of years, allowing the shrinkage of the ice mantle from its outer limit to one of the later stages of its retreat, it will only be necessary to find an explanation for one fact, namely: the extension of till outwardly for several miles beyond the so-called "terminal moraine." But it will be necessary also to suppose the long continuance of the same peat-forming conditions about the southern ice-margin.

If, on the other hand, the till which overlies the peat in Mower county be not the horizontal extension, and equivalent of that which overlies it in Blue Earth county, and there were no lateral extension of the till beyond the ice-margin as above presumed, then the two tills in Mower county, separated by this bed of peat, show the existence of two glacial epochs in Minnesota prior to that which has been described as *the last* glacial epoch, and the clay which covers the peat in Blue Earth county may be a pebbly clay of a semi-lacustrine origin — one of the incidents of the ice-retreat through the Undine region.†

A specimen of this ancient peat from Blue Earth county was sent to Mr. B. W. Thomas, of Chicago, for microscopic examination. He reports: "I send you slides of diatoms, sponge spiculæ, Radiolarius, etc., from the interglacial peat you so kindly sent me. So far as I have yet noted, all of the forms are fresh-water, about the same as those now found in your fresh-water ponds, streams, swamps, etc."— N. H. W.]

* Final report, vol. I, pp. 363 and 390.

† Final report, vol. I, p. 442.

Clays.— On Friday afternoon, October 17th, Mr. S. F. Alberger took me to see the place where he has obtained the pottery clay, containing the Cretaceous leaves. This point is about half way between Chalk run and the farm house on the Le Sueur river bank, and as to thickness, etc., of deposit, and over and underlying matter, are well described on pages 435 and 436, volume one, of the final report of the geological survey of Minnesota. In the cut whence come the fossil leaves, appears on one side a large boss of rock, whether connected with other rock or not within the bank, could not be determined. The part exposed was about four feet each way, is very much water-worn, seems on the surface formed of a white clay very firm and hard. Throughout this clay are scattered, very thickly, little rounded masses of the size of peas, quite distinct in form from the clay, but seeming to possess the same composition. Within, the rock is more siliceous; grains of free sand cover a freshly broken surface. Along the side of the rock mass are markedly seen the lines of stratification, exactly as seen on the water-worn or weathered surface of the Shakopee at the cement works and elsewhere. (See figure 11.)

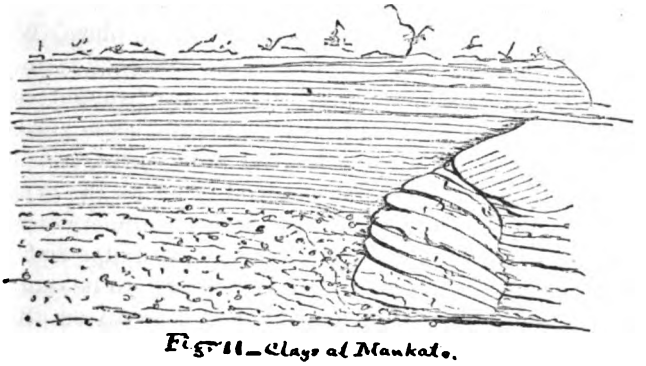


Fig 11—Clays at Mankato.

A little further along the bluff toward Chalk run is an exposure of the Cretaceous clay, made during last winter. Here the clay rests on a floor of rock, whose edge is not exposed. This rock has the "fawn" color, hardness and general external properties of some of the softer layers of the Shakopee. It is worthy of note that the white clay on the Jordan sandstone is from twenty to thirty feet below this; and incidentally that from fragments of stone found in this white clay on the southeast corner of Chalk run bluff, where it is just now being uncovered for use this winter, the white clay seems to lie on eroded surfaces of the Jordan.

[NOTE.—The following observations were made at the pottery works of Mr. Alberger, in October, based on a quantity of material for use derived from his clay-pit a short distance above the bluff at the railroad crossing, the same point as above illustrated by Prof. Bechdolt. The clay here used contains numerous leaves, and through the kindness of Mr. Alberger a collection has been made and submitted to Dr. Leo Lesquereux, of Columbus, O., for determination. The relative position of the white clay and the other parts of the bluff is here determined by the statements of Mr. Alberger.

In the white (kaolinic) clay lying directly on the sandrock are small concretions of silica, about as large as pin-heads. They have a dull or dirty amethystine color, and are generally in definite horizons, or very thin sheets running coincident with a kind of structural fibre in the clay itself, though in general the clay is homogeneous and massive.

The white clay is sometimes concretionary—at least lumps of a coarsely concretionary, kaolinic, clay, resembling that seen under the Cretaceous at two miles below the Lower Sioux Agency*—are found in the bed which Mr. Alberger uses for tiling and fire brick. They probably appertain to the conglomerate, which is closely associated with the potter's clay at that place. When he screens the conglomerate, in order to get siliceous material for his fire-brick, these concretionary lumps are brought to light. Some pieces are small, like a hickory-nut, and some are as large as a peck measure. They are derived apparently, *en masse*, directly from the bed of decayed material lying on the crystalline rock-surface at the time of the Cretaceous submergence. The most of the white kaolinic clay, as it lies in, under and on the Shakopee and Jordan formations, is supposed to be due to the reassorting and distributing agency of that ocean on that pre-existing mass of soft material; said mass being the result of weathering and decay of the crystallines through Silurian and Carboniferous times. In the same conglomerate are silicified corals and brachiopods of Silurian and even Devonian age, found as water-rounded pebbles. Mr. Alberger's tests seem to show that this conglomerate consists of purer silica, though containing some chert, etc., than the sandrock lying under the Shakopee limestone. The underlying sandrock, he says, will fuse in the heat he produces, rather easily, but the crushed pebbles of this conglomerate he cannot fuse.

* See the second annual report, p. 187.

The following facts and observations were derived from a late visit to the cement works of the Standard Cement company, at Mankato.

1. They do not use the whole rock now, as they did at first, but only the lower ten feet (about ten feet).

2. They have had some poor cement, but this is now obviated by making some selection of the rock.

3. Mr. Bodé, chemist at Milwaukee, has analyzed all the strata, and given careful attention to the differences of composition, the strata being numbered from near the top downward. Nos. 3, 6 and 7 had nearly the same composition, but they are using all below No. 3.

4. The upper portion is burned for quicklime, or is sold at twenty-five cents per load for common building rock, the purchaser hauling it away.

5. The company have sold in advance all the cement they can make from this date to Jan. 1, 1885, and say they will continue in operation into the winter as late as possible, even if they "have to shed the quarry" — the product for the season being from 25 to 30 thousand barrels, at $1.50 per barrel.

6. The irony crust on the Shakopee is not so much due to the superposition of something new, by accretion, on the surface, as to a change in the Shakopee itself to the depth of about half an inch. The crystalline facets of the dolomitic rock can be seen plainly preserved within the irony crust at some distance from the line of transition from the rock to the crust. There is also a somewhat different color and texture in the lower part of the crust.

7. If the clay lying under the limerock is of the same age as the limerock (Cambrian), as supposed by Prof. Bechdolt, and as indicated by the appearances at the quarry, and by the intercalation of their clay beds within the beds of the limerock at higher levels, that seem to be of the same age as that below — I can only explain it on the hypothesis that the Shakopee lies unconformably, near here, on the crystallines, and that at the time of its deposition, a submergence like that which preceded the Cretaceous kaolinic clays, took place, thus bringing the older decayed material within the strata of the Cambrian. If that be the case the Shakopee will be found somewhere near Mankato lying on the crystalline rocks (though here it lies on the Jordan), and the white underlying clay will there be still thicker, though at remoter points the same clay is known to disappear wholly from this ho-

rizon. By a later (Cretaceous) submergence the same process took place again and gave Cretaceous kaolinic deposits, the result of wash from both crystalline and Cambrian areas. This whole hypothesis, however, as yet seems to me unnecessary, since I think all the clay within and under the Shakopee may be attributed to the insinuating action of the water of the Cretaceous ocean on the pre-existing weather-cracks and openings of the Shakopee, carrying the fine clay to the deepest recesses, wherever the water could enter — and especially because we know of no such overlapping of the later Cambrian unconformably on the crystallines. — N. H. W.]

XVIII.

FOSSIL ELEPHANT IN WINONA COUNTY.

BY PROF. JOHN HOLZINGER.

STATE NORMAL SCHOOL,
WINONA, Feb. 11, 1885.

Prof. N. H. Winchell, Minneapolis, Minn.,

DEAR SIR: If my memory serves me correctly, you inquired quite a while ago about some remains of a mastodon supposed to have been found in Winona county, and now deposited in our Normal School museum. I wrote to you then that we have only the remains of a mastodon found near Dubuque, Iowa. And this was in fact all that I knew at the time. Recently when I removed the precious remains of said animal I discovered the incongruity of the crown of a tooth, and a fragment of a tusk with the rest of the skeleton. Since then Prof. Morey, former principal of our school, has gone through the Museum with me, and when I indicated to him the want of agreement in the structure of the several parts, he informed me that the tooth and fragment of tusk did not belong to Prof. Woodman's collection* at all. These pieces, he said, were added during his administration; and he knew positively that they were found by the workmen on the Chicago & Northwestern railway, near Stockton, and that in the same locality was found a large antler of an elk, about three feet long. But the striking point of it all is that tooth and tusk seem to be not parts of a mastodon; but, to judge from the grinding surface, and size of the tooth, they belonged rather to a species of Elephas. The question is, was it the common Elephas primigenius.

Hoping that it is not too late for you to make use of this note, I remain, cordially yours, JOHN M. HOLZINGER.

* The Dubuque specimen had been purchased of Prof. H. T. Woodman.

[NOTE—On making further inquiries concerning the exact location of the finding of these remains, Prof. Holzinger ascertained, from Dr. Cole, of Winona, that he had brought a piece of a tusk from Stockton, taken from a clay-bank within forty rods of the railroad crossing of the highway, and deposited it in the Normal School museum, some twenty years ago. Also, that Hon. Thomas Simpson sent the greater part of the piece of tusk to the museum of the State Historical Society. Mr. Simpson also stated that the tooth now in the possession of the Normal School was found in the same place as the tusk, only a little later, during the cut through the clay-bank. This clay-bank is the loess-loam of the region, lying in the valley where Stockton is situated, between high rock-bluffs composed of the St. Croix and St. Lawrence formations.*

By the kindness of Prof. Holzinger this tooth was submitted for examination and description, and the following notes were made. It is illustrated by the figure on plate II.

It is not an entire tooth, but apparently less than one-half of the original. It is five inches long, fore and aft, on the crown, and three and a half inches in width. Entire plates are wanting from both ends, so that the piece, as shown in the figure, represents the central triturating surface of the crown, well worn. It is five and three-fourths inches deep perpendicularly, with signs of having lost an inch or more. The flat crown shows eight enamel plates (one at each end), the average distance between their centres being three-fourths of an inch. The thickness of these plates, though double, averages less than one-quarter of an inch; and hence the intervening cementum averages a little more than one-half inch in thickness. These plates are, therefore, "attenuated and concentrated," as Falconer remarks of American representatives of the Elephas primigenius. The plate represents the natural size of the crown of the tooth.

The dentine (in the centre of the plates) is so thin in some places as to be hardly visible. The enamel plates are direct and uncrimped, hardly undulating as they pass from one side of the tooth to the other. This might be *Elephas primigenius*, Blu., as that species was at first understood to range in America.

In 1838, Dr. C. Briggs, a member of the corps of the first geological survey of Ohio, first described Elephas Jacksoni, from Jackson county, Ohio, as distinct from E. primigenius, Blu.† and

* See the final report, vol. i, p. 238.

† Mather's first annual report, 1838. This name was first applied by Briggs in the American Journal of Science, vol. xxxiv, 1838.

Mr. Billings was disposed to have this name cover all specimens, except E. Columbi, "found in America as far north as the United States and Canada," (Canada then was Upper and Lower Canada, and not the Dominion, as now,) including that described by himself from Burlington Heights, near Hamilton, at the western extremity of lake Ontario, found in 1852.

De Kay, however, according to Leidy in "Extinct mammalian fauna" (vol. vi, of the second series of the Philadelphia Academy of Natural Sciences, Journal), named the American specimens E. americanus, a name which Leidy revives and continues, both in the above publication and in the volume of Hayden's survey (vol. i), entitled "Contributions on the extinct vertibrate fauna of the western territories," p. 238. Billings, however, attributes the origination of the specific name americanus Leidy, at the date of 1853. (See Can. Nat., vol. viii, p. 146.)

Dr. Falconer established E. columbi in 1857, concluding it ranges about the gulf of Mexico and southward. (Natural History Review, Jan., 1863.) He seems to include in it E. jacksoni, of Briggs, and its representatives from other places.

E. imperator, Leidy (1858), was at first thought to be new, because associated, as supposed, with a peculiar geological fauna of a different (earlier) age, but Leidy now rather includes it (with columbi) in americanus, and thinks its relations to the other fossils with which it was reported to be associated are not established satisfactorily.

E. texanus (Blake or Owen, 1858) is satisfactorily proved by Falconer to be a synonym of E. columbi. (Nat. History Review, Jan., 1863.)

Billings in the Canadian Naturalist, vol. viii, p. 146, regards columbi and jacksoni as distinct from each other, and from primigenius.

This Stockton specimen is quite distinct from the Montana specimens described in the tenth annual report, in the thinness of the plates, and the large amount of cementum between them; and if either be different from the primigenius, of Blumenbach, it is that from Stockton, and might be distinguished by Leidy's name americanus. According to Falconer, however, probably the best of English authorities, these would all be classed as primigenius.—N. H. W.]

XIX.

BOULDER-CLAYS.

ON THE MICROSCOPIC STRUCTURE OF CERTAIN BOULDER-CLAYS AND THE ORGANISMS CONTAINED IN THEM. BY DR. GEORGE M. DAWSON, D. S., F. G. S., F. R. S., CAN., ASSOCIATE R. S. M., AND ASSISTANT DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA. *

In a paper read before the Academy in January, 1884, and printed in the bulletin of the Academy (vol. i, No. 4), H. A. Johnson, M. D., and B. W. Thomas, F. R. M. S., gave the results of an investigation by them of microscopic organisms in the boulder clay of Chicago and vicinity. This paper refers principally to certain remarkable bodies first found by these gentlemen in 1865–6–7 in specimens of the clay through which the lake tunnel which supplies the city of Chicago with water from lake Michigan was being constructed. On the completion of the tunnel large numbers of the same bodies were observed in the filtrate from the city water supply, and which were subsequently proved to be identical with organisms described in 1871 by Sir J. W. Dawson from the Devonian shales of Kettle Point, lake Huron. They have since been observed in the Devonian rocks of a number of widely separated localities, and are now believed by Sir J. W. Dawson to be the spores of rhizocarps.† Mr. Thomas, in a note to the paper first quoted, refers to the additional discovery in boulder-clay from Minnesota, sent to him by Prof. N. H. Winchell, of several species of Foraminifera, evidently derived from the Cretaceous rocks of that region. Since this announcement Mr. Thomas has mounted for the microscope and examined many samples of boulder-clays from various places, and has favored me from time to time with

* Read before the Chicago Academy of Sciences June 9, 1885.

† Proc. A. A. A. S., 1883, and Can. "Record of Science," vol. i. See also paper by Mr. J. M. Clarke, American Journal of Science, vol. xxix, p. 284.

a number of his preparations. He has also kindly prepared and mounted specimens of several boulder-clays and allied materials collected in Manitoba and the Saskatchewan region. At his request the notes made by me on these last and on a few of those first mentioned are here offered. This paper must, however, be understood to be merely of a preliminary and general character, being based on the examination of less than one hundred microscopic preparations. It may, it is hoped, be supplemented later by a more detailed report, including the discussion of a larger suite of specimens from a greater number of localities.

The minute investigation of these boulder-clays has resulted in the discovery of many objects which, while evidently of organic origin, are very difficult to name or classify, and require comparison with a wide range of bodies and reference to many works for that purpose. Mr. Thomas has also found that even in the case of those clays with which he is most familiar each new lot of preparations mounted is almost sure to show forms not before observed, and that the field is an ever-widening one.

It is now, therefore, proposed merely to denote the classes of objects so far observed in the various boulder-clays, and when possible the genera to which the organisms belong, without attempting to catalogue them specifically. Neither is it here intended to enter into any further discussion as to the nature of the Sporangites occurring in some of the clays.

It should also be stated that most of the objects on the many slips examined have been indicated by maltwood markings by Mr. Thomas, a circumstance greatly reducing the amount of labor involved in going over the material.

[It should be explained that the material referred to in the succeeding notes is that part of the boulder-clay which is composed of particles of medium size, from which the very fine matter has, as a rule, been separated by decantation. This again has been sized by repeated decantations at intervals of one, two, or three minutes. Mr. Thomas states that the greater number of examples of a given form are frequently thus obtained in material of a certain grade of fineness.]

Boulder-clays of Chicago and vicinity.

The preparations examined representing the boulder-clay of Chicago and vicinity are as follows: From Chicago lake tunnel, 86 feet down, 5 slides; North Chicago boulder-clay, 60 feet down, 11; North Chicago clay, 64 feet down, 2; North Chicago, 65 feet

down, 10; corner of Washington and Clark streets, 8 feet down, 1; or 29 in all. These are so similar in their general characters and the class of objects which they present that they may be considered together.

The inorganic material in these clays, as represented by the above preparations, consists largely of quartz sand, in which few well-rounded grains appear, most being sub-angular and many quite angular and unworn. With these is about the usual proportion of bottle-green particles of hornblende, with a few of mica and feldspar. Nearly one-half of the entire material is, however, composed of flattened and rounded grains of fine shale, which have a dark brown color and granular texture by transmitted light. One or two of the quartz grains show included crystals and many hold fluid or gas cavities. The bodies of organic origin most commonly met with are referable to *Sporangites huronensis*, of Sir J. W. Dawson, of the Devonian shales. These are extremely abundant, and the shale particles already described are doubtless derived from the disintegration of the same beds. They are in some instances very well preserved, but are also present in all stages of decay, and in many cases hold a quantity of granular, shaly, or clayey matter in their interiors. Besides these a specimen occurs in the material from the lake tunnel of entirely different character. It is a partly flattened sphere of 0.2 m. m. in diameter, with radiating and concentric structure, brownish color, and very small central cavity, or nucleus. This is precisely similar to the bodies from the Devonian rocks described and figured as Macrospores by Mr. Clarke in his paper above referred to. Two more bodies of the same class appear in other preparations, but are more nearly transparent, and evidently in a different state of preservation. To one of them a small fragment of the matrix attaches and serves to show that both of these may have come from a limestone bed.

Next in abundance to the Sporangites is a class of bodies the true nature of which is very doubtful. Of these at least twelve large fragments were noted in the preparations under discussion, with many smaller and less characteristic pieces. They may be described as spines or spicules, generally cylindrical, but sometimes trough-shaped or triangular in cross-section, averaging about .05 m. m. in diameter, and of pale yellowish brown color. Their structure is very finely granular, and the outer surface more or less roughened, as though from erosion. They

are in some cases distinctly tubular, with a small central cavity; in others have a thick medullar portion, which is poorly defined but differs somewhat in texture from the exterior. Some of the fragments terminate in acute points, others have a slightly swollen, rounded end, and one was observed to be doubly terminated and nearly spindle shaped. They appear to be calcareous, but whether this is their original condition or the result of mineralization is uncertain. They can scarcely be chitinous, being much paler in color than other specimens of this character met with in some of the preparations. So many organisms may have produced spines or spicules resembling these bodies that it is not yet possible to assign them definitely. They do not appear to be sponge spicules, but as their color and texture is not unlike that of the next class of objects, they may possibly be partly mineralized chitinous setæ of Annelids, derived from some of the subjacent rocks. Their diversity in shape is such that they must either represent several species or belong to different parts of some organism in connection with which several types of appendage of this character are developed. See Fig. 12.

Among the most interesting bodies found in these clays are certain comblike objects which are regarded as annelid jaws. Of these four, all fragmentary, have been observed. They were at first supposed to be teeth from the lingual ribbon of some mollusk, but on more careful examination were found to be unlike the teeth of any mollusk of which figures can be found, and, moreover, to correspond almost exactly in form with some of the annelid jaws described by Mr. G. J. Hinde from the Silurian and Devonian rocks of Canada.* See Fig. 13.

One of the specimens shows a series of long and curved prongs. Three others apparently belong to a single type, in which a nearly flat plate is armed along one edge by a series of small, close denticles arranged somewhat obliquely to the line of attachment. See Fig. 14. Like the bodies last described they are of a pale straw color, differing in this respect from Mr. Hinde's specimens, which are said to be shining and black; but this difference may arise from the mode of preservation. They exhibit no reaction with polarized light, and are smooth and not distinctly granular. The ends of the prongs or denticles are worn and roughened as though by use.

Other bodies occurring in these preparations in smaller numbers need not be referred to in detail. Two broken specimens

* Quarterly Journal of the Geological Society, 1879, p. 370.

evidently represent Ostracoda. They show no well marked sculpture, but a minutely granular structure. The most perfect is .31 m. m. in length. A third specimen, somewhat larger, and also broken, is either a small Sphærium or a very young specimen of some larger shell. All three have adhering to them brownish shaly particles, which appear to indicate their origin, though it must be remarked that the shell substance is very well preserved and fresh looking. Still another specimen is a broken piece of the edge of a large calcareous shell or carapace, beautifully marked, and possibly that of an ostracod of another species. The remaining objects observed are mere fragments, quite indeterminate in character. Among these are small pieces of a delicate ribbed shell, the ribs being square in cross-section. A rather large chitinous fragment, striated extremely, but without any other apparent structure, and one or more pieces of straight tubular siliceous spicules, probably belonging to some sponge.

The probable sources of the organic bodies in these clays is discussed subsequently in connection with those from other places.

Boulder-clays from Bloomington, Ill., 107 feet down.

[This clay immediately underlies an interglacial deposit of soil and peaty matter with remains of wood, etc.]* Of this clay five preparations only have been examined. The coarse material is here chiefly quartz sand, of which by far the larger proportion is sub-angular. There are also a few grains of amethystine quartz, showing sharp conchoidal fracture. Several quartz grains show inclusions, one of verysmall hexagonal red crystals, probably hematite. Hornblende grains are moderately abundant, but shaly fragments such as those which make up a large proportion of the material from the Chicago clays are almost or altogether wanting. A few Sporangites exactly like those previously noticed occur, together with one or two specimens of the pale brownish granular spines, or setæ, found in the Chicago clays. A small, flat, curved, finely ribbed body in one of the slips resembles part of the edge of a carapace. While therefore not altogether wanting in this clay, organic traces appear to be very scantily represented.

* This stratum of soil is about 6 feet thick, and underlies 101 feet of boulder-clay. I do not know the thickness of the clay deposit below the inter-glacial soil. — B. W. T.

Boulder-clays from Meeker county, Minnesota.

This material is derived from a well shaft sunk in Meeker county, at a depth of about twenty-two feet, and was transmitted to Mr. Thomas by Prof. N. H. Winchell, state geologist of Minnesota. Mr. Thomas has made a large series of preparations from it, a number of which I have had the opportunity of inspecting.

As the Foraminifera contained in these preparations are being named and catalogued by Messrs. A. Woodward and B. W. Thomas, the remarks here given are confined entirely to the general character and contents of the clay, with the object of comparing it with those from other localities.

The coarser material from this clay, as it appears in the preparations, is chiefly quartz sand, which is generally sub-angular, though with some well-rounded grains. Hornblende and mica appear in about the usual proportions, and two quartz grains with very beautiful inclusions were noticed, one being probably either hornblende or rutile, the other possibly apatite. A large proportion of the material, however, consists of rounded grains of shale, of gray or greenish-gray color by transmitted light, and not nearly so dark as the shale mixed with the Chicago clays. In specimens boiled in nitric acid, the shaly fragments have become reddish from the oxidation of the iron.

Of organic bodies present in these specimens of Minnesota clay, the Foraminifera are most prominent and important. They are evidently derived from the Cretaceous strata, and resemble those found in the western development of these rocks, both specifically and in mode of preservation.

Ratalidæ and *Textularidæ* are most abundant, though specimens of *Globigerina* and other genera also occur. Next in abundance to the Foraminifera are remains of Radiolaria. Some difficulty was experienced in deciding the true nature of fragments of these bodies at first met with, but the subsequent discovery of numerous and often well preserved specimens, and the observation by Mr. Thomas that they resist boiling in nitric acid, now leaves no doubt as to their character. Several genera and quite a number of species are represented, and it will eventually be possible to determine many of these forms specifically. Most appear to belong to the Polysphæridæ and Cystidæ of Haeckel's classification. The constant occurrence of these bodies with the Cretaceous Foraminifera in the Minnesota preparations and in those from

other places, with their absence from these materials not equally characterized by the Foraminifera, leaves little room to doubt the common origin of both. Among miscellaneous objects from the Minnesota clay may be mentioned a few fragments apparently identical with the minutely granular spines or setæ described as occurring in the Chicago clays; also two broken portions of stout siliceous spicules, about .026 m. m. in diameter, one smooth, the other tuberculated; both tubular, and probably belonging to some sponge. Lastly, a single specimen of a very curious body, of straggling and irregular form, composed of numerous expansions differing in shape and size and pretty uniformly pitted, but connected by narrow, smooth necks. As this is in one of the preparations which has been treated with acid, it must be siliceous. I can only suggest that it may be the siliceous cast of some foraminifer like *Aschemonella catenata* of Norman, the arenaceous test of which has been composed of calcareous particles which have left pitted impressions on the cast. Against this is the fact of its small size, it being about .2 m. m. only in greatest diameter.

Boulder-clay from Crete, Saline county, Nebraska.

This material, Mr. Thomas informs me, was obtained from a single small excavation. It was forwarded to Mr. Thomas by Prof. G. D. Swezey, and is described by him in a letter to Mr. Thomas as a blue clay underlying the loess. The inorganic matter in the preparations made from it consists largely of fine angular and sub-angular quartz grains, with a small proportion of green hornblende and much shale or earthy limestone in little particles which differ in color and texture. It is extremely rich in organic forms, chiefly Cretaceous Foraminifera, so much so that it seems probable that it is largely composed of the debris of the Niobrara division of that formation, and that a complete study of its contents would practically include that of all the forms occurring in the chalky limestone of that stage. The present notice of it must therefore be considered as of the most general and preliminary character only. Of this material a suite of thirty-one preparations has been examined, and in an enumeration of about one hundred of the best preserved forms nearly fifty per cent belong to the *Textularidæ*, the remainder being made up in nearly equal proportions of *Globigerinidæ*, *Ratalidæ*, miscellaneous Foraminifera of other families, and radiolarians, resembling, and in some cases

identical with, the Minnesota species. Fragments of calcareous prisms from the shell of Inoceramus and in the finer matter specimens of coccoliths and rhabdoliths also occur; all resembling in every respect similar bodies found in the Niobrara rocks of Nebraska and Manitoba.*

Many of the Foraminifera are completely filled with calcite, while others are still partially hollow, and yet others are filled partly with calcite and partly with black carbonaceous or bituminous matter. Of objects of an unusual character two may be specially referred to. A rod-like body about .2 m. m. in length, narrowed near the middle, though broken at one end, and marked by numerous pits in linear series. This may be a small spine from some echinoderm. Also a hollow conical tooth or spine, evidently that of a fish, also broken, but still .25 m. m. in length.

Boulder-clay from a well at Rosenfeld, Manitoba.

This material, sent to me under the name of "hard-pan," was obtained at a depth of 135 feet, in a well bored by the Canadian Pacific railroad company at Rosenfeld, Manitoba. It formed, mixed with gravel and boulders, a layer of eighteen feet in thickness, below the post-glacial alluvial deposits of the Red river valley and resting on a Silurian shale. As the well was bored with an ordinary percussion drill, it is possible that some matter from the alluvial deposits above referred to may have been mixed with the specimen of "hard-pan," but so far as examined these alluvial deposits do not hold any organic forms. Numerous small particles of steel from the edge of the drill occur in the six preparations representing this clay.

The inorganic constituents are coarse in texture, quartz grains, of which nearly one-half are perfectly rounded, as usual predominating. Bottle-green hornblende is moderately abundant, as are also fragments of feldspar and limestone, but shaly materials are almost altogether wanting. Bodies of organic origin are rather scarce, Foraminifera, however, being most common, and a Textularia of the type of T. globulosa is characteristic. A few Rotalidæ are also present, with broken chambers of other Foraminifera. The examination of a greater quantity of the material would doubtless lead to the discovery of all the ordinary Cretaceous types.

* See a paper by the writer in the Canadian Naturalist, 1874.

Boulder-clay from the South Saskatchewan river ten miles east of the mouth of the Swift Current.

This and the two following localities in the Canadian northwest territory are represented by specimens collected by Mr. R. G. McConnell. The three localities lie between the 106th and 108th meridians, and represent a portion of the great drift-covered area of the northern plains. The material from this place is, as usual, largely siliceous, but there is a larger proportion than common of coarse, thoroughly-rounded quartz grains. Hornblende and other crystalline minerals from the Laurentian or Huronian are also present, and there is a notable quantity of amethystine quartz in angular fragments. Comminuted very fine-ground gray shale is moderately abundant. Bodies of organic origin are not frequent. In pretty carefully examining a series of six preparations, about ten only were met with. These are *Textulariæ* and rotaline Foraminifera, with one very small *Globigerina*, and a couple of radiolarians; one very perfect, oval and .09 m. m. in longest diameter. (*Haliomma?*) A fragment was also found of bony substance, showing haversian canals and probably portion of a ganoid scale. There is also in these preparations a number of rounded and flattened grains, nearly transparent, though in some cases with a more opaque central spot, and surface minutely and regularly roughened. These were eventually determined by comparison to be fragments of some pearly shell, probably that of Unio, a form quite abundantly represented in the Cretaceous and Laramie rocks of the region. The appearance of an opaque nucleus in some examples appears to result from the non-penetration of the mounting medium to the centre of the larger grains.

Boulder-clay from ten miles north of the South Saskatchewan, east of Missouri Coteau, township 21, *range* 10, *west of 3d principal meridian.*

The material in six preparations from this clay differs from the last described only in the much greater quantity of comminuted shaly matter of a reddish-brown tint. Bodies of organic origin are here again scarce. No Foraminifera were found. Two or three broken pieces of minute rod-like pitted objects, very doubtfully referred to small spines of some Echinoderm, and evidently identical in character with that previously described from Saline county, Nebraska, were detected. Those occurring here are

about .015 m. m. in diameter. Another somewhat similar object is rather stouter and with a roughened surface without regular markings. A small broken piece of some chitinous test was also observed, but on the whole this material is very barren.

Boulder-clay from the South Saskatchewan, fifteen miles above the Elbow.

In the preparations from this clay — eighteen in number — the sandy material is much finer than in the two last. It is nearly half composed of shaly fragments of brown color, the quartz sand being also rather more angular than usual. It is richer in organic forms than either of the other specimens from the neighborhood of the South Saskatchewan. About half a dozen specimens of Foraminifera were recognized in the preparations, one being probably a small *Discorbina*, others *Textulariæ*, and broken chambers of *Globigerinæ*. These are not so well preserved as in some of the other clays, and in some cases the shell itself appears to have been removed, leaving only a rough cast in calcite. Radiolarians are here (so far as the examination of a small quantity of material can be accepted as conclusive) even more abundant than Foraminifera; spherical, oval and turbinate forms all being represented, and in some cases in such connection with fragments of the abundant shaly material as to leave no doubt as to their common origin with it. Small, partly-rounded prisms from the shell of *Inoceramus* are also present, together with a few pieces of straight hollow siliceous spicatæ, one specimen of a minutely granular spine or seta, with a distinct medullar portion like some previously noticed, and .026 m. m. in diameter, and one of a portion of a body like that previously referred with doubt to an Echinoderm spine.

In inquiring as to the derivation of the various organic bodies in the clays, it is necessary to consider the situation of each locality with reference to known areas of the older rocks from the disintegration of which they may have come. The Sporangites so abundant in the Chicago clays have been definitely traced to the shales of the Devonian age, and have doubtless been brought to their present position from outcrops to the northward in the Michigan peninsula. It has already been stated that the bodies supposed to be Annelid jaws may probably have been derived from the same beds, or from others of the Devonian or Silurian rocks of this part of the country. With regard to the remaining bodies no definite statement can at present be returned,

though there is every reason to believe that they might very well have come from the same rocks.

In the clays from Bloomington, in the centre of the state of Illinois, Sporangites are again the most characteristic bodies, though much less numerous in correspondence with the greater distance from the shale outcrops. A few other objects associated with these are not dissimilar to those in the Chicago clays.

Meeker county, from which the specimens of Minnesota boulder-clay were derived, is in the southern and central portion of the state, and is underlaid, according to Prof. N. H. Winchell's map, by rocks of the Cambo-Silurian period.* As might be anticipated from the absence of Devonian rocks both in this locality and the whole region to the north and northeast, Sporangites have not been observed in this clay. While the greater part at least of the organisms are evidently referable to the Cretaceous rocks, the locality lies to the northeast of the generally recognized edge of that formation. Prof. Winchell has, however, proved the existence of a number of outliers of Cretaceous beyond the main area occupied by these rocks, and it is probably from one of these, possibly not remote from the actual position of the clay, that the Foraminifera and Radiolariæ have come.

The clay from Crete, Saline county, Neb., is, as already observed, so rich in Cretaceous forms as to lead to the belief that it is largely composed of the debris of the chalky limestone of the Niobrara stage, and may rest upon or lie very near to the outcrop of these beds. I am not in a position to state whether the geology of the district bears out this conclusion. The map shows at least that Cretaceous rocks underlie this part of the state.

The material from Rosenfeld, Manitoba, shows a smaller number of forms, but these are equally characteristic of the Niobrara stage, the outcrop of which, though concealed by alluvial and other deposits, can not be many miles west of the position of the well, and also runs northward along the base of the Pembina escarpment, having been recognized at a point about fifty miles northwest of Rosenfeld on the Boyne river. ("Geology and Resources of the 49th Parallel," p. 78.) As there is little probability of the existence of any Cretaceous rocks directly north or to the northeastward of this place, the occurrence of Cretaceous

* Dr. Dawson here is slightly in error as to the rocks underlying Meeker county. So far as known they are the crystalline rocks of the Archæan, probably overlain by the shales of the Cretaceous.—N. H. W.

Foraminifera would tend to show that material derived from the northwest had been incorporated with the boulder-clay of this district.

The three localities near the South Saskatchewan may be treated of together in so far as the origin of their organic constituents is concerned. The general movement of the material composing the glacial deposits of the northern plains in a southwesterly direction has already been demonstrated (see "Quarterly Journal of the Geological Society, 1875," p. 605; "Report of progress of the geological survey of Canada, 1882–4," p. 139) and it would appear that the Cretaceous Foraminifera must also have been carried from the vicinity of the eastern Cretaceous outcrops at a great distance. It is true that the clays here rest on Cretaceous beds, but these are not as a rule calcareous, or such as to yield Foraminifera in the state of preservation of these found in the clays. The Niobrara limestones are not only unknown in the entire district from which the clays come, but their place appears to be taken in this region by the Belly river beds, which are arenaceous and argillaceous. Other organic fragments present in these clays may well have been derived from the Cretaceous or Lamarie beds of the immediate neighborhood.

In reviewing the general bearings of the microscopical examination of these boulder-clays, representing as they do a few points only, scattered over a wide area in the central portion of the continent, it would be unwise to endeavor to draw any very definite or too general conclusions. The field appears to be a promising one for future inquiry, and the present paper can be regarded only as in the restricted sense, preliminary. It would appear, however, that of all the organic bodies met with none can be assigned with certainty to the glacial period or era of deposition of the boulder-clay itself. The origin of most can be traced unequivocally to the older rocks, from which they have been derived, and incorporated with the boulder-clays. Of all the bodies enumerated the only ones which, on account of their presence in clays, holding otherwise different sets of forms, may possibly be of contemporaneous origin with them, are siliceous sponge (?) *spicules* and the peculiar spines or setæ several times referred to in the foregoing. To these may be possibly added the Astracoda from the Chicago clay. While it is therefore probable that the examination of these organic fragments will serve to throw additional light on the direction of transport of material during the Glacial period — a point of particular value

over the wide area of the plains, where the soft character of the rock precludes the test of direction of striation — it has so far failed to afford any certain information as to the actual conditions prevailing during that period. The negative evidence, reinforced by the fact that derived bodies have been perfectly preserved, so far as it goes, leads to a belief in the great scarcity of contemporary life. The occurrence of inter-glacial peats and the induration of wood and other vegetable matters in the boulder-clays of a number of widely separated localities in the west (see "Vegetable remains in drift deposits of the Northwest," by Prof. N. H. Winchell, Proc. A. A. S., 1875; "Report of Progress of the Geological survey of Canada, 1882–4," p. 144) prove, however, that life was not constantly absent, and it may therefore reasonably be anticipated that further search will eventually lead to the definition in the clays of at least such contemporary organisms as may have been derived from these inter-glacial deposits, and possibly of others strictly contemporaneous with the boulder-clays themselves. The well-rounded character of a considerable proportion of the sand in some of the specimens points to prolonged water action, but there is no means of deciding to what extent in each case previously rounded sand grains have been included in the clays. The comparatively unworn appearance of the majority of the Foraminifera and other delicate objects, on the contrary, indicate rather tranquil conditions of deposit, and negatives the occurrence in the case of these materials of any extensive differential motion in the substance of the clay itself, which would infallibly have destroyed these very fragile organisms. Mr. Hugh Miller, in a carefully marked out paper on "Boulder glaciation" ("Royal physical society, Edinburgh," vol. viii, p. 157), describes a fluxion structure in the Scottish till or boulder-clay, and notes instances of sand grains so shaped and striated as to represent microscopic glaciated boulders which he conceives to have been "slidden along and glaciated in these places in the clay." No confirmation of this observation is afforded by these clays. Though many grains of an elongated shape show what might at first be taken for such striation, it is apparent in almost every case on close examination that the lines are really structural and that the shape of the grains is here, as in ordinary sands, governed to a great extent by the pre-existing cleavage or jointage planes of the material of which they are composed.

The microscopical examination of these boulder-clays bears

out the conclusion arrived at from their microscopic character, that, while largely composed of far-traveled material, they invariably contain a considerable proportion of material of local, or proximately local, origin.

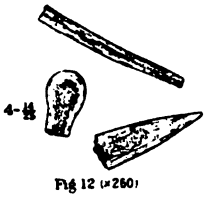


Fig 12 (×260)

Fig 13 (×260)

Fig 14 (×260)

Organisms from the Chicago boulder-clays

XX.

ON THE FORAMINIFERA OF THE BOULDER-CLAY, TAKEN FROM A WELL-SHAFT 22 FEET DEEP, MEEKER COUNTY, CENTRAL MINNESOTA.

BY A. WOODWARD AND B. W. THOMAS. (JULY 1, 1885.)

[NOTE.—In the course of Mr. Thomas' investigation of the rhizocarps of the Devonian shales found in the Chicago boulder-clay, several years ago, he made a request for samples of boulder-clay from Minnesota, for comparison. About that time Mr. Dickson, living a few miles southwest from Litchfield, in Meeker county, who was sinking a common well for domestic purposes, on his farm, had found numerous fragments of Cretaceous lignite in the blue till into which he was sinking his well. These pieces attracted attention, in the public press, as indications of "coal." Thereupon Mr. Dickson, through the agency of Attorney J. N. Cross, of Minneapolis, sent me a lot of it, accompanied by a fair sample of the boulder-clay itself. This boulder-clay contained not only other pieces of lignite, but many bits of shale such as has been referred to the Cretaceous formation whenever seen in similar circumstances anywhere in the state. These were sent to Mr. Thomas. Subsequently much more shale was obtained at the same place and forwarded to Mr. Thomas. The microscopic fossils that Mr. Thomas has thus brought to light, and which are described, named and illustrated in the following paper by Messrs. Woodward and Thomas, are therefore fossils of the Cretaceous formation, and are not indigenous to the boulder-clay itself. The paper might be entitled, correctly, *The foraminifera of the Cretaceous*, since these bits of shale can be referred, without any doubt, to the Cretaceous, which is known to underlie large areas of the till in that part of the state, and since similar fossils have been found in the Cretaceous shales, *in situ*, by Dr. G. M. Dawson, in the escarpment of Pembina mountain, in Manitoba, (*Canadian Naturalist*, new series, vol. vii, p. 252). Still later a quantity of Cretaceous shale, much more calcareous, and referable to the *Niobrara*, of Meek & Hayden, was obtained at Redstone, New Ulm, through Mr. B. Juni, and sent to Mr. Thomas for a similar examination.

Through the intelligent co-operation and zeal of Mr. Thomas, united with the labor and skill of Mr. Woodward, in examining and illustrating these objects, an entirely new field of research is opened up to the geologists of Minne-

sota. Mr. Thomas has mounted all these objects for microscopic study, and has marked most of the forms on the slides with Maltwood numbers, and Mr. Woodward has drawn up the paper, which sets forth the result of their joint labor. It is to be hoped that this field may be further searched, and that a full account may finally be given of the entire microscopic fauna of the Cretaceous.— N. H. WINCHELL.]

The main object of this paper is simply to give some idea of the various forms of foraminifera to be found in the boulder-clays of Minnesota. We do not pretend that it is by any means a monograph or a perfect and complete paper, for we think from what observations we have made, and the number of species found from comparatively one or two localities, that a much fuller and more extensive paper could be written. But it cannot be done in a limited time, and it will require material from a great many localities, and several years of labor.

As it is we have been very successful, far beyond our expectations, considering the small amount of material at hand, from which we have prepared a large number of slides, selecting about eighty for this investigation, and by using a one-fifth objective we have identified the following species:

Textularia globulosa, Ehrenberg. Common.
T— agglutinans, d'Orbigny. Not common.
T— turris, d'Orbigny. Rare.
Spiroplecta Americana, Ehrenberg. Rare.
Gaudryina pupoides, d'Orbigny. Quite rare.
Bulimina pupoides, d'Orbigny. Rare.
Bolivina punctata, d'Orbigny. Rare.
Uvigerina canariensis, d'Orbigny. Rare.
Globigerina bulloides, d'Orbigny. Quite rare.
G— cretacea, d'Orbigny. Common.
G— marginata, Reuss. Quite rare.
Lagena favoso-punctata, Brady. Common.
Orbulina universa, d'Orbigny. Very common.
Operculina complanata, Defrance, sp. Rare.
O— complanata, var.
granulosa, Leymerie. Rare.

The material washed from the boulder-clays is at least 95 per cent sand, and the shells being in most cases filled solid with foreign matter, generally calcite, cannot be separated from it by drying, and scattering over distilled water, as we do recent foraminifera. Consequently it requires much work, time and

patience to secure a few good specimens of these interesting fossils.

These we have endeavored to figure and describe, giving the synonyms, and when possible using the original descriptions.

Sub-Kingdom PROTOZOA.

Class RHIZOPODA.

Order *Reticularia.*

(Foraminifera.)

TEXTULARIDÆ.

Sub-Family I.—TEXTULARINÆ.

TEXTULARIA, Defrance.

Textularia globulosa, Ehrenberg.

(Plate III, figs. 1-5.)

Textularia globulosa, EHRENBERG. Abhand. Akad. Berlin. (1838) 1839. pl. iv.
Textularia globulosa, DAWSON, 1874. Can. Nat. vol. vii, p. 253, fig. a.
Textularia globulosa, SCHARDT, 1884. Etudes Geol. Sur. le Pays—D'Enhaut. Bull, Soc, Vaud., vol. xx, p. 74.

"*T.—globulosa*, testula microscopica superficie lævi, in adulta longiore quam lata, articulis globosis." (Ehrenberg. (1838) Abhand. Akad. Berlin, p. 135.)

T.—globulosa, microscopic test with a smooth surface, adult forms longer than wide, with spherical or globular chambers.

Locality. Meeker county, Minn.

The species being generally distributed throughout the west. Is quite common in the boulder-clays of central Minnesota, also in the Cretaceous of Nebraska and Dakota.

Textularia agglutinans, d'Orbigny.

(Plate III, figs. 6, 7.)

Textularia agglutinans, D'ORBIGNY, 1839, Foram. Cuba, p. 144, pl. i, figs. 17, 18, 32-34.
Textularia agglutinans, SEGUENZA 1862, Atti dell' Accad. Gisenia, vol. xviii, (ser. 2), p. 112, pl. ii, fig. 4.
Plecanium sturi, KARRER, 1864, Sitzungsb. d. k. Ak. Wiss. Wien, vol. l, p. 704, pl. i, fig. 1.
Textularia agglutinans, PARKER and JONES, 1865, Phil. Trans., vol. clv, p. 369, pl. xv, fig. 21.
Plecanium agglutinans, REUSS, 1869, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lix, p. 452, pl. i, figs. 1, 2.
Textilaria agglutinans, MOEBIUS, 1880, Foram. von Mauritius, p. 93, pl. ix, figs. 1–8.
Textularia agglutinans, BRADY, 1884, Report Foram. H. M. S. Challenger. Zool., vol. ix, p. 363, pl. xliii, figs. 1–3, vars. figs. 4, 12.

Textularia. Testa elongato-conica, rugoso-agglutinate, alba, lateraliter convexiuscula; postice cuneata; loculis largis, ultimis convexis; apertura semi-lunari. d'Orbigny (Foram. Cuba, p. 144).

Test elongate, conical, rugose, agglutinous (from grains of sand) white, laterally convex, posteriorly cuneate, segments large, the last convex, aperture semi lunate.

Locality, Meeker county, Minn.

Textularia turris, d'Orbigny.

(Plate III, fig. 8.)

Textularia turris, d'ORBIGNY, 1840, Mem. Soc. Geol. France, vol. iv, p. 46, pl. iv, figs. 27, 28.
Textularia turris, PARKER and JONES, 1863, Ann., and Mag. Nat. Hist., ser. 3, vol. xi, p. 97.
Textularia turris, BRADY, 1884, Report on Foram. H. M. S. Challenger. Zool., vol. ix, p. 366, pl. xliv, figs. 4, 5.

"*Textularia turris* is round in transverse section, elongate, and tapering. It differs from *Textularia trochus* chiefly in its greater proportionate length and its rougher exterior, as well as in its frequent irregularity of contour." Brady (loc. cit).

Locality, Meeker county, Minn.

We have been able so far to find but one specimen, while it

appears to be comparatively common in the Cretaceous beds of France, Bohemia, England and Ireland.

SPIROPLECTA, Ehrenberg.

Spiroplecta americana, Ehrenberg.

(Plate III, fig. 9.)

Spiroplecta americana, EHREN., 1854, Mikrogeolgie, pl. xxxii, I. figs. 13, 14; II. fig. 25.

Spiroplecta americana, BRADY, 1884, Report on Foram. H. M. S. Challenger. Zool., vol. ix. p. 376, pl. xlv, fig. 24, a. b.

"The test is usually much compressed, and widens rapidly towards the distal end; the lateral edges are thin and slightly lobulated, the chambers somewhat inflated, and the septal lines correspondingly depressed on the exterior; the walls are thin and smooth." Brady (loc. cit).

Locality, Meeker county, Minn.

This species does not seem to be very widely distributed.

The specimens figured by Ehrenberg were from the Cretaceous beds of Missouri and Mississippi.*

GAUDRYINA, d'Orbigny.

Gaudryina pupoides, d'Orbigny.

(Plate III, fig. 10.)

Gaudryina pupoides, D'ORBIGNY, 1840, Mem. Soc. Geol. France, vol. iv, p. 44, pl. iv, figs. 22-24.

Gaudryina pupoides, Id., 1846, Foram. Foss. Vien., p. 197, pl. xxi, figs. 34-36.

Gaudryina subglabra, GUMBEL, 1868, Abh. d. k. bayer. Akad. Wiss., II. cl., vol. x, p. 602, pl. i, fig. 4.

Gaudryina pupoides, BRADY, 1884. Report on Foram. H. M. S. Challenger. Zool., vol. ix, p. 378, pl. xlvi, figs. 1-4.

"*Gaudryina pupoides* is an easily recognised species. Its dimorphous mode of growth is generally very apparent, and its variability is limited to such features as the number of segments, the relative length and breadth of the test, and the degree of lateral compression. In recent shells the walls are thin and calcareous, smooth externally, and almost invariably of a greyish hue; fossil specimens sometimes exhibit a slightly rough exterior. In form

*Brady. *Report on the Foraminifera, H. M. S. Challenger*, p. 376.

and position the aperture resembles that of the typical *Textulariæ*, but it is often surrounded by a raised lip or borden." Brady (loc. cit.).

Locality, Meeker county, Minn.

Bulimina pupoides, d'Orbigny.

(Plate III, fig. 11.)

Bulimina pupoides, D'ORBIGNY, 1846, For. Foss. Vien., p. 185, pl. xi, figs. 11, 12.

Bulimina pupoides, WILLIAMSON, 1858, Rec. For. Gt. Br., p. 62, pl. v, figs. 124, 125.

Bulimina presli, var. pupoides, PARKER and JONES, 1862, Introd. Foram., Appendix, p. 311.

Bulimina pupoides, TERRIGI, 1880, Atti dell' Accad. Pont., ann. xxxiii, p. 193, pl. ii, figs. 30-34.

Bulimina pupoides, BRADY, 1884, Report on Foram., H. M. S. Challenger. Zool., vol. ix, pp. 400, 401, pl. l, fig. 15, a. b.

Shell oblong; obtuse, especially at the inferior lateral surface; composed of numerous segments, arranged in an indistinct spiral, and exhibiting a tendency to form three oblique vertical rows; segments remarkably ventricose and prominent; the anterior one usually more oblong than the rest, from its anterior part not being embraced, as all the preceding ones, by the next segment. Septal plane convex; semilunar. Septal orifice single, placed near the umbilical border of the septal plane, and usually characterized by a curious obliquity at its inner part, owing to the two lips of the orifice not meeting at their umbilical extremities, but passing one behind the other. Texture hyaline; transparent; when examined, after being mounted in Canada balsam, through a high power, it is seen to be perforated by innumerable minute foramina. Williamson's *Recent Foraminifera Gt., Br.* p. 62.

Locality, Meeker county, Minn.

Sub-Family 2.— BULIMINIÆ.

BOLIVINA, d'Orbigny.

Bolivina punctata, d'Orbigny.

(Plate III, fig. 12.)

Bolivina punctata, D'ORBIGNY, 1839, Foram. Amer. Merid., p. 61, pl. viii, figs. 10-12.

Bolivina antiqua, Id., 1846, Foram. Fo-s. Vien., p. 240, pl. xiv, figs. 11–13.
Grammostomum polystigma, EHRENBERG, 1854, Mikrogeologie, pl. xix, fig. 84.
Grammostomum caloglossa, EHRENBERG, Ibid. pl. xxv, figs. 17, 18.
Bolivina punctata, BRADY, 1864, Trans. Linn. Soc. Lond., vol. xxiv, p. 468, pl. xlviii, fig. 9, a, b.
Bulimina presli, var. (*Bolivina*) *punctata*, PARKER and JONES, 1865, Phil. Trans., vol. clv, p. 376, pl. xviii, fig. 74.
Bolivina elongata, HANTKA, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv, p. 65, pl. vii, fig. 14.
Bolivina antiqua, TERRIGI, 1880, Atti dell' Acad. Pont., ann. xxxiii, p. 196, pl. ii, fig. 40.
Bolivina punctata, MOEBIUS, 1880, Foram von Mauritius, p. 94, pl. ix, figs. 9, 10.
Bolivina punctata, BRADY, 1884, Report on Foram. H.M.S. Challenger. Zool., vol. ix, p. 417, pl. lii, figs. 18, 19.

B. testa elongata, compressa, conica, antice obtusa, postice acuminatea, alba, punctata, lateraliter subcarinata; loculis numerosis, obliquis, undulatis, ultimo obtuso; apertura simplici. D'Orbigny (Foram. Amer. Merid., p. 63).

Test elongated, compressed, conical, obtuse, anteriorly, acuminated posteriorly, white, punctate, sub-carinate on sides, with numerous oblique undulate segments, the last obtuse, aperture simple.

Locality, Meeker county, Minn.

LAGENIDÆ.

Sub-Family 1.— LAGENINÆ.

LAGENA, Walker and Boys.

Lagena favosa-punctata, Brady.

(Plate IV, figs. 32, 33, 34, 38.)

Lagena favoso-punctata, BRADY, 1881, Quart. Journ. Mic. Sci., vol. xxi, N. S. p. 62.
Lagena favoso-punctata, BRADY, 1884, Report on Foram. H. M. S. Challenger. Zool., vol. ix, pl. lviii, fig. 35, pl. lix, fig. 4, pl. lxi, fig. 2.

"Test ecto-or ento-solenian, shape variable; surface areolated or reticulated, with a conspicuous orifice or perforation in the middle of each area or depression. Length $\frac{1}{75}$th inch (0.34 mm.) or less." Brady (loc. cit.)

Locality, Meeker county, Minn.

Sub-Family 3.—POLYMORPHININÆ.

UVIGERINA, d'Orbigny.

Uvigerina canariensis, d'Orbigny.

(Plate IV, fig. 37.)

"*Testæ pineiformes minusculæ*," SOLDANI, 1798, Testaceographia, vol. ii, p. 18, pl. iv, figs. E, F, G, H.

Uvigerina nodosa, var. B, D'ORBIGNY, 1826, Ann. Sci, Nat., vol. vii, p. 269, No. 3.

Uvigerina canariensis, Id. 1839, Foram. Canaries, p. 138, pl. i, figs. 25-27.

Uvigerina urnula, D'ORBIGNY, 1846, For. Foss. Vien., p. 189, pl. xi, figs. 21, 22.

Uvigerina irregularis, BRADY, 1865, Nat. Hist. Trans. Northd. and Durham, vol. i, p. 100, pl. xii, fig. 5.

Uvigerina proboscidea, SCHWAGER, 1866, Novara-Exped., geol. Theil, vol. p. 250, pl. vii, fig. 96.

Uvigerina farinosa, HANTKEN, 1875, Mi·theil. Jahrb. d. k. ung. geol. Anstalt, vol. iv, p. 62, pl. vii, fig. 6.

Uvigerina canariensis, BRADY, 1884. Report on Foram. H. M. S. Challenger· Zool., vol. ix, p. 573, pl. lxxiv, figs. 1-3.

U. testa oblongo-conica, punctata, albida; spira conica, anfractibus quinis minime convexis; loculis convexis, per quamque spiram trinis; apertura rotunda; siphone brevi. d'Orbigny. (Foraminifera Canaries, p. 138.)

Test oblong conical, punctate, whitish with a conical spire of five whorls slightly convex, segments convex, three to each whorl of the spire, aperture round, siphon short.

Locality, Meeker county, Minn.

GLOBIGERINIDÆ.

GLOBIGERINA, d'Orbigny.

Globigerina cretacea, d'Orbigny.

(Plate III, figs. 14-16. II, fig. 19.)

Globigerina cretacea, D'ORBIGNY, 1840, Mem Soc. Geol. France, vol. iv, p. 34, pl. iii, figs 12-14.

Globigerina foveolata (pars), EHRENBERG, 1854. Mikrogeologie, pl. xxiv, fig. 49.

Globigerina libani, EHRENBERG, Ibid., pl. xxv, fig. 30.

Planulina pachyderma, Id., Ibid., pl. xxv, fig. 31.

Rotalia pertusa, Id., Ibid., pl. xxiv, fig. 41.
Rotalia aspera, Id., Ibid., pl. xxvii, figs. 57, 58, pl. xxviii, fig. 42, pl. xxxi, fig. 44.
Rotalia globulosa, Id., Ibid., pl. xxvii, fig. 60, pl. xxviii, figs. 40, 41, pl. xxxi, figs. 40, 41, 43.
Rotalia densa, Id., Ibid., pl. xxvii, fig. 62.
Rotalia quaterna, Id., Ibid., pl. xxvii, fig. 53, pl. xxviii, fig. 34.
Rotalia rosa, Id., Ibid., pl. xxvii, fig. 54.
Rotalia pachyomphala, Id., Ibid., pl. xxvii, fig. 55.
Rotalia tracheotetras, Id., Ibid., pl. xxvii, fig. 35.
Rotalia perforata, Id., Ibid., pl. xxviii, fig. 36, pl. xxix, fig. 2.
Rotalia protacmœa, Id., Ibid., pl. xxviii, fig 37.
Rotalia laxa, Id., Ibid., pl. xxviii, fig 38, pl. xxix, fig. 1, pl. xxxi, fig 42.
Rotalia centralis, Id., Ibid., pl. xxviii, fig 39.
Globigerina cretacea, BRADY, 1879. Quart. Journ. Micr. Sci., vol. xix, N. S., p. 285.
Globigerina cretacea, BRADY, 1884. Report on Foram. H. M. S. Challenger. Zool., vol. ix, p. 596, pl. lxxxii. Fossil specimens, fig. 11, a -c.

"Test rotaliform, much compressed; superior face flattened or only slightly convex, inferior side depressed towards the centre and excavated at the umbilicus, periphery obtuse and lobulated; composed of about three tolerably distinct convolutions, the outer most consisting of from five to seven segments; segments relatively small, subglobular; apertures opening into an umbilical vestibule. Diameter, $\frac{1}{50}$th inch (0.5 mm.)" Brady (loc. cit.)

Locality, Meeker county, Minn.

This species is very abundant in the boulder-clays of Minnesota, but the specimens we examined were quite fragmentary; perfect examples rare.

Globigerina bulloides, d'Orbigny.

(Plate III, fig. 13.)

"*Polymorpha Tuberosa et Globulifera*," SOLDANI, 1791, Testaceographia, vol. i, pt. 2, p. 117, pl. cxxiii, figs. H, I, O, P.
Testæ tuberosæ, etc., Id., 1798. Ibid., vol. ii, p. 20, pl. vi, figs. dd., ee.
Globigerina bulloides, D'ORBIGNY, 1826, Ann. Sci. Nat., vol. vii, p. 277, No. 1.—Modeles, No. 17 (young), and No. 76.
Globigerina bulloides, Id., 1839, Foram. Amer. Merid., p. 37.
Globigerina bulloides, Id., 1839, Foram. Canaries, p. 132, pl. ii, figs 1-3, 28.
Globigerina hirsuta, Id., Ibid., p. 133, pl. ii, figs. 4-6.
Globigerina siphonifera, Id., 1839, Foram. Cuba, p. 95, pl. iv, figs. 15-18.
Globigerina bulloides, Id., 1846, For. Foss. Vien., p. 163, pl. ix, figs. 4-6.

Globigerina concinna, REUSS, 1849, Denkschr. d. k. Akad., Wiss. Wien., vol. i, p. 373, pl. xlvii, fig. 8.
Globigerina diplostoma, Id., Ibid., p. 373, pl. xlvii, figs. 9, 10.
Globigerina depressa, EHRENBERG, 1854, Mikrogeologie, pl. xix, fig. 92.
Globigerina foveolata (pars), Id., Ibid., pl. xxii, fig. 74.
Globigerina cretæ, EHRENBERG, 1854, Mikrogeologie, pl. xxvi., fig. 44; — pl. xxx, fig. 38.
Globigerina stellata, Id., Ibid., pl. xxvi, fig. 45.
Globigerina ternata, EHRENBERG, 1854, Mikrogeologie, pl. xxxv B., figs. 5, 6.
Planulina poroteras, Id., 1854, Ibid., pl. xx, II. fig. 16.
Planulina pertusa, Id., Ibid., pl. xxii, fig. 75.
Planulina stigma, Id., Ibid., pl. xxv, fig. 29.
Rotalia rudis, Id., Ibid., pl. xxiv, figs 35, 36.
Rotalia leptospira, Id., Ibid., pl. xxiv, fig. 39.
Rotalia senaria (pars), Id., Ibid., pl, xxiv, fig. 40.
Ptygostomum orphei, Id., Ibid., pl. xxxv, B, figs. 1, 2.
Phanerostomum atlanticum, Id., Ibid., pl. xxxv, B., figs. 3, 4.
Globigerina bulloides, KUBLER and ZUINGLI, 1866, Neujahrsblatt, v. d. Burgerbib. in Winterthur, pt. 2, p. 22, pl. iii, figs. 30, 31.
Globigerina taminensis, Id., Ibid., p. 24, pl. iii, fig. 26.
Globigerina bulloides, GUMBEL, 1868, Abh. d. k. bayer. Akad. d. Wiss., II. cl, vol. x, p. 661, pl. ii, fig. 106.
Globigerina alpigena (?), Id., Ibid., p. 661, pl. ii, fig. 107.
Globigerina eocæna, Id., Ibid., p. 662, pl. ii, fig. 109.
Planulina mauryana, EHRENBFRG, 1873, Abhandl. d. k. Akad. Wiss. Berlin (1872), p. 388, pl. iii, fig. 1.
Planulina globigerina, Id., Ibid., p. 388, pl. iii, fig. 3.
Planulina megalopentas, Id., Ibid., p. 388, pl. iv, fig. 7.
Pylodexia platyletras, Id., Ibid., p. 388, pl. iii, fig. 14.
Aristerospira omphalotetras, Id., Ibid., p. 388, pl. iii, fig. 15.
Globigerina detrita, TERQUEM, 1875, Anim. sur la Plage de Dunkerque, fasc. i, p. 31, pl. iv, fig. 4. a-c.
Globigerina bulloides. TERQUEM, 1875, Anim. sur la Plage de Dunkerque, fasc. i, p. 31, pl. iv, fig. 5, a. b.
Globigerina bulloides, BRADY, 1879, Quart. Journ. Micr. Sci., vol. xix, N. S., p. 71.
Globigerina bulloides, BRADY, 1884, Report on Foram. H. M. S. Challenger. Zool., vol. ix, p. 593, pl. lxxix, figs. 3-7.

"Test spiral, subtrochoid; superior face convex, inferior more or less convex but with deeply sunken umbilicus, periphery rounded, lobulated; adult specimens composed of about seven globose segments, of which four form the outer convolution; the apertures of the individual chambers opening independently into the umbilical vestibule. Diameter, sometimes $\frac{1}{10}$th inch (0.63 mm.), but oftener much less." Brady (loc. cit).

Locality, Meeker county, Minn.

Globigerina marginata, Reuss.

(Plate IV, figs. 20 22.)

Rosalina marginata, REUSS, 1845, Verstein. bohm. Kreid, pt. i, p. 36, pl. xiii, fig. 47.
Rosalina marginata, JONES, 1853, Ann. and Mag. Nat. Hist., ser. 2, vol. xii, p. 241, pl. ix, fig. 7.
Rosalina marginata, REUSS, 1854, Denkschr. d. k. Akad. Wiss. Wien, vol. vii, p. 69, pl. xxvi, fig. 1.
Discorbina marginata, Id., 1854, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lii, p. 12, No. 2.
Globigerina marginata, PARKER and JONES, 1865, Phil. Trans., vol. clv, p. 367.
Rotalia marginata, GUMBEL, 1870, Sitzungsb. d. k. bayer. Akad. Wiss., vol. ii, pp. 283, 287.
Globigerina marginata, REUSS, 1874, Das Elbethalgebirge in Sachsen, 2ter Theil, p. 112, No. 2.
Globigerina marginata, BRADY, 1879, Quart. Journ. Micr. Sci., vol. xix, N. S., p. 74.
Globigerina marginata, BRADY, 1884, Report on Foram. H. M. S. Challenger. Zool., vol. ix, p. 597, wood cut, fig. 17.

"Test rotaliform, much compressed; superior face convex, inferior face also convex but with a sunken umbilical recess, peripheral edge thin or subcarinate; segments numerous, five or six in the last convolution, the outer margin of each segment exhibiting a well-marked narrow border; apertures opening into the umbilical vestibule. Surface of living specimens beset with spines. Diameter, $\frac{1}{10}$th to $\frac{1}{25}$th inch (0.5 to 1 mm)." Brady (loc. cit).

Locality, Meeker county, Minn.

This species we are in some doubt about, it resembles so closely in some respects *G-linnæana*, while in others *Pulvinulina menhardii*; but the weight of evidence is in favor of *G. marginata*. Reuss.

ORBULINA, d'Orbigny.

Orbulina universa, d'Orbigny.

(Plate IV, figs. 25-31.)

"*Polymorpha Sphærule vitreæ*," SOLDANI, 1791. Testaceographia, vol. i, pt. 2, p. 116, pl. cxix, figs. I-N.
Orbulina universa, D'ORBIGNY, 1839, Foram. Cuba, p. 3, pl. i, fig 1.
Orbulina universa, Id., 1839, Foram. Canáries, p. 122, pl. i, fig. 1.
Miliola (Monocystis) arcella EHRENBERG, 1854, Mikrogeologie, pl. xxx, fig. i.

Miliola sphærula, Id., Ibid., pl. xxxi, fig. 1, a. b. c.
Orbulina granulata, var. *atra*, COSTA, 1856, Atti dell' Accad. Pont., vol. vii, p. 116, pl. xi, fig. 2.
Orbulina granulata, var. *areolata*, Id., Ibid., p. 117, pl. xi, fig. 4.
Orbulina universa, Id., Ibid., p. 114, pl. xi, fig. 5.
Orbulina universa, WILLIAMSON, 1858, Rec. For. Gt. Br., p. 2, pl. 1, fig. 4.
Orbulina punctata, TERQUEM, 1862, Foram du Lias, 2*ième* mem., p. 432, pl. v, fig. 5.
Globigerina (*Orbulina*) *universa*, OWEN, 1867, Journal Linn. Soc., Lond., vol. ix, Zool., p. 149, pl. v, fig. 1.
Globigerina (*Orbulina*) *continens*, Id., Ibid., figs. 3, 4.
Globigerina (*Orbulina*) *acerosa*, Id., Ibid., fig 2.
Orbulina universa, BRADY, 1859, Quart. Journ. Micr. Soc., vol. xix, N. S., p. 75.
Orbulina universa, Id., 1884, Report on Foram. H. M. S. Challenger, Zool., vol. ix, p. 608, pls. lxxviii, lxxxi, figs. 8-26, pl. lxxxii, fig. 1-3.

Generic character. Shell free, regular, spherical, hollow; perforated by innumerable very minute foramina, visible only under a high magnifying power, septal orifice single, small, situate at some point on the periphery of the shell; without any marginal projection; often invisible.*

Spec. char. Spherical; parietes minutely granular, of a pale, grayish-yellow hue. Texture finely arenaceous. Septal aperture small; normally round, but usually irregular, and sometimes entirely closed up by the inspissated gelatinous sarcode, so as to be invisible. Diam. $\frac{1}{60}$—$\frac{1}{80}$.*

Locality, Meeker county, Minn.

It is a very cosmopolitan species, being found very abundantly, both living and fossil.

Several of the specimens figured by us seem to be covered with minute spines, as heretofore spoken of by other writers.

NUMMULINIDÆ.

Sub-Family 3.—NUMMULITINÆ.

OPERCULINA, d'Orbigny.

Operculina complanata, Defrance, sp.

(Plate IV, fig. 35.)

"*Operculum minum*," PLANCUS, 1739, Conch. Min., p. 18, pl. iii, fig. 1, A. B. C.
Lenticulites complanata, DEFRANCE, 1822, Dict. Sci. Nat., vol. xxv. p. 453.

* Williamson's *Recent Foraminifera G. B.* 1857.

Lenticulites complanata, BASTEROT, 1825, Mem. Geol. Env. Bordeaux, pt. i, p. 18.
Operculina complanata, D'ORBIGNY, 1826, Ann. Sci. Nat., vol. vii, p. 281, pl. xiv, figs. 7-10, Modele, No. 80.
Operculina ammonea, LEYMERIE, 1846, Mem. Soc. Geol. France, ser. 2, vol. i, p. 359, pl. xiii, fig. 11, a. b.
Operculina complanata, RUTIMEYER, 1850, Schweizer Nummuliten—terrain, p. 108, pl. iv, fig. 56.
Operculina arabica, CARTER, 1853, Journ. Bombay Br. R. Asiatic Soc., vol. iv, p. 437, pl. xviii.
Operculina hardici, D'ARCHIAC and HAIME, 1853, Descr. Anim. Foss, du groupe nummulitique de l'Inde, p. 346, pl. xxxv, fig. 6, a. b. c.
Operculina complanata, PARKER and JONES, 1861, Ann., and Mag. Nat. Hist., ser. 3, vol. viii, p. 229.
Operculina studeri, KAUFMANN, 1867, Geol. Beschreib. des Pilatus, p. 151, pl. ix, figs. 1, 2.
Operculina marginata, Id., Ibid., p. 152, pl. ix, fig. 4.
Operculina complanata, MOEBIUS, 1880, Foram. von Mauritius, p. 104.
Operculina complanata, BRADY, 1884, Report on Foram. H. M. S. Challenger. Zool., vol. ix, p. 743, pl. cxii, figs. 3, 4, 5, 8.

Operculina complanata, var. granulosa, Leymerie.

(Plate II, fig. 36.)

Amphistegina fleuriausi, D'ORBIGNY, 1826, Ann. Sci. Nat., vol. vii, p. 304, No. 7 (name only), fide Reuss.
Operculina granulosa, LEYMERIE, 1846, Mem. Soc. Geol. France, ser. 2, vol. i, p. 359, pl. xiii, fig. 12, a. b.
Amphistegina fleuriausi, REUSS, 1861, S tzungsb. d. k. Ak. Wiss. Wien, vol. xliv, p. 308, pl. i, figs. 10-12.
Operculina irregularis, REUSS, 1864, Deukschr. d. k. Acad. Wiss. Wien, vol. xxiii. p. 10, pl. i, figs. 17, 18.
Operculina granulata, GUMBEL, 1868, Abhandl. d. k. bayer. Akad. d. Wiss., II. cl., vol. x, p. 663, pl. ii, fig. 111, a. b.
Operculina var. granulosa, BRADY, 1884, Report on Foram. H. M. S. Challenger. Zool., vol. ix, p. 743, pl. cxii, figs. 6, 7, 9, 10.

As there seem to be some doubt and difference of opinion in regard to this species and variety, we will only undertake to give the generic description given by H. B. Brady.

The test of the typical *Operculina* is a thin complanate disk, composed of three or four broad convolutions, symmetrically arranged, and equally visible on both faces. The central portion of the disk is usually somewhat thicker than the outer whorls, and not unfrequently almost umbonate; the earlier convolutions are more or less embracing, the later whorls evolute. The segments are usually very numerous, of gradually increasing size, and typically very short in the direction of growth, as compared

PLATE I.

PAGE.

Fig. 6. *Lingula calumet*, magnified four diameters.
a, impression of the beak of the longer valve (concave). *b*, impression of the shorter valve (concave). *c*, convex surface of a small specimen. *d*, concave impression of the longer (?) valve..... 65

Fig. 7. *Paradoxides barberi*, natural size..... 67

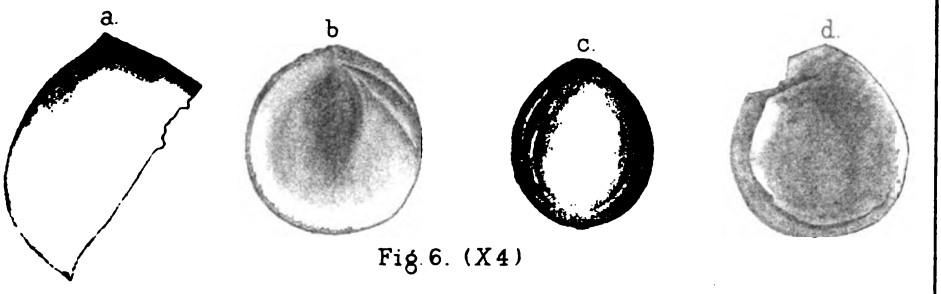
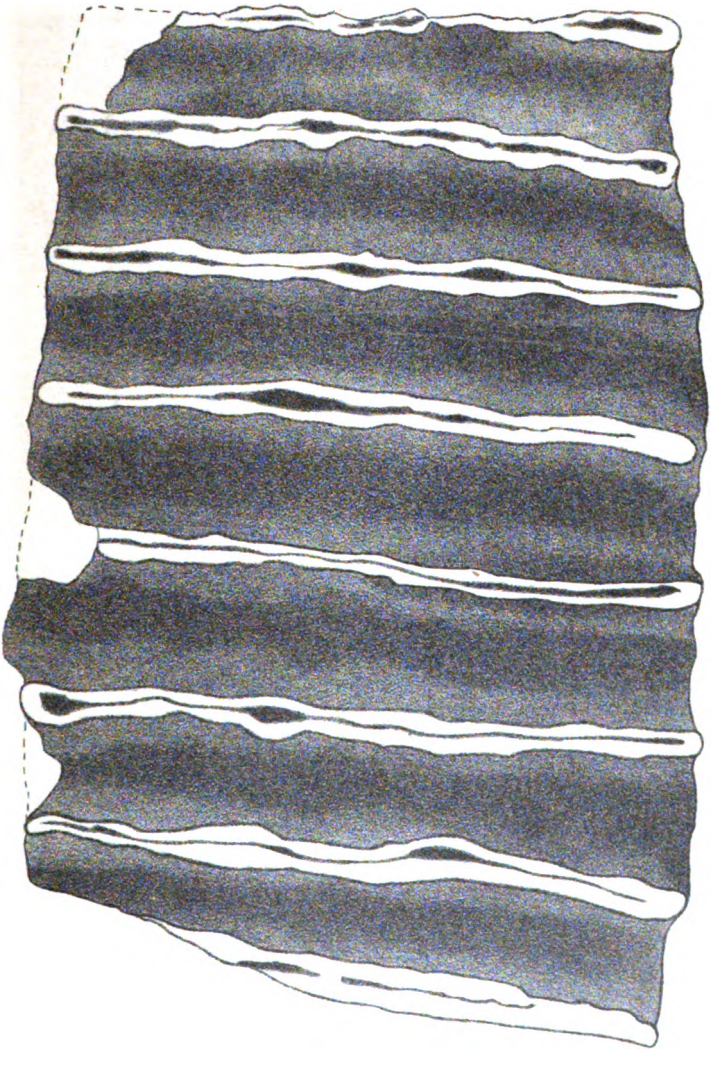


Fig. 6. (X4)

Fig. 7.

Julius Bien & Co Lith

PLATE II.



Julius Bien & Co. Lith.

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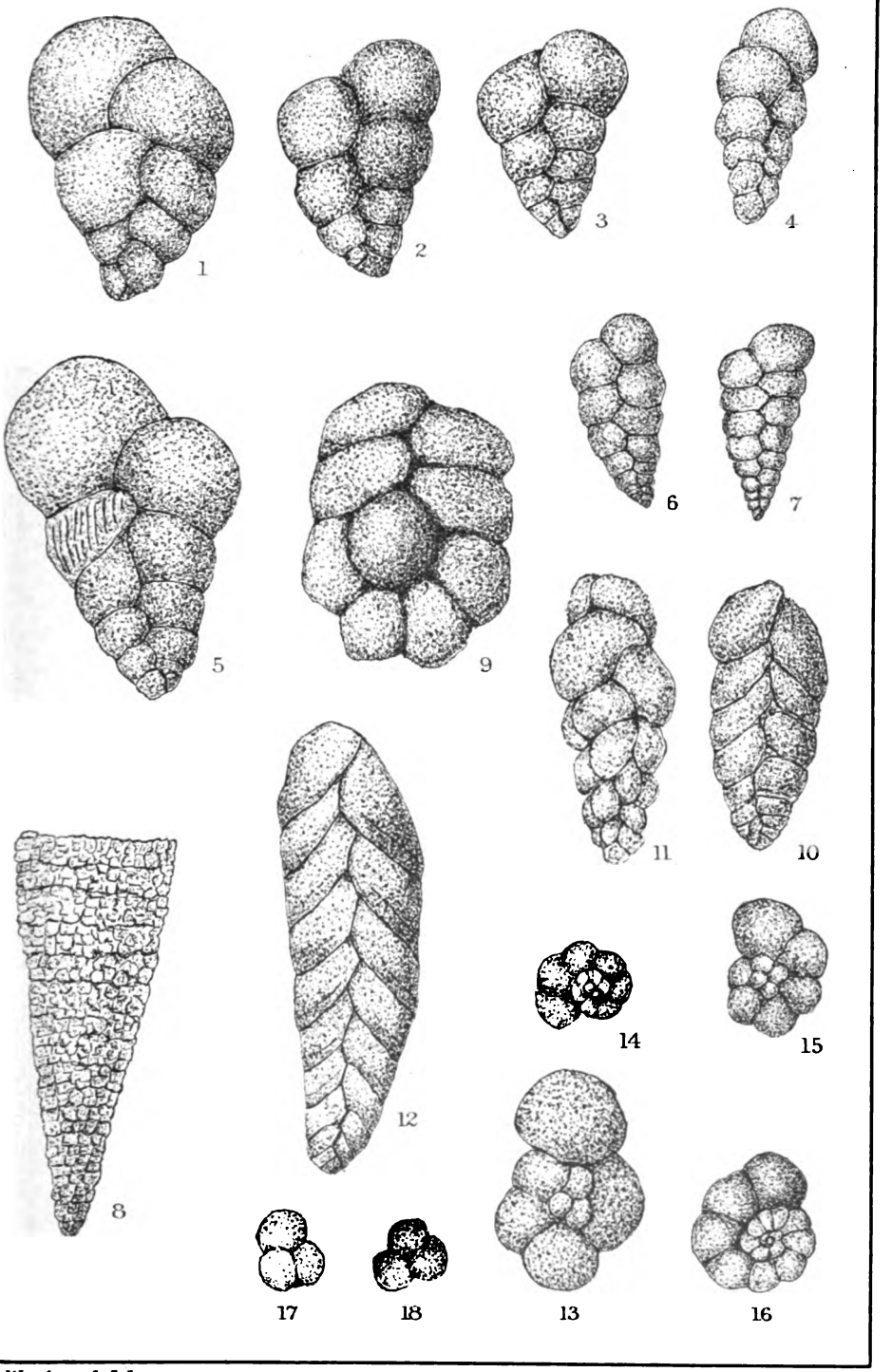

A. Woodward del.

PLATE IV.

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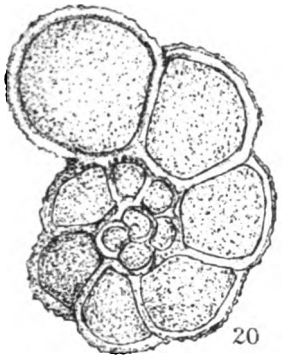
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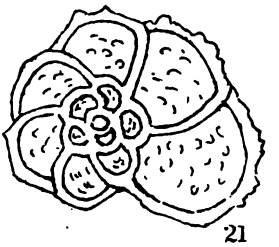
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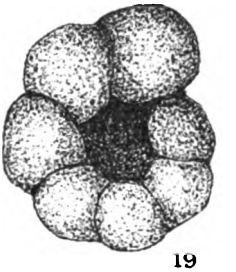
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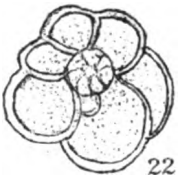
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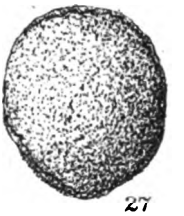
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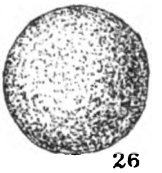
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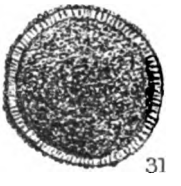
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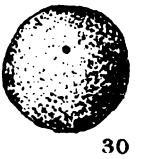
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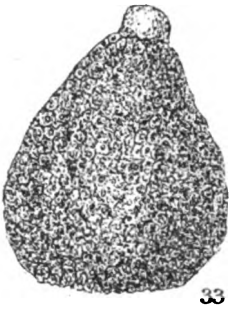
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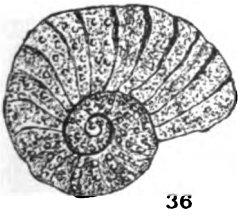
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A Woodward del.

with their width radially; they are for the most part produced on a uniform plan, but near the finish are often irregular, both as to shape and size (Pl. cxii, figs 3, 4 and 6). The exterior is sometimes smooth; but, more frequently, either the sutures or the surface of the chambers, or both, are ornamented with exogenous granules, papillæ or tubercles, which, as a rule, are more strongly developed near the centre than on the later whorls; and in the small, northern variety of the genus, the septal lines and periphery are distinctly limbate. The general aperture is a straight or slightly curved fissure at the inner margin of the final segment, close to the periphery of the previous convolution; but the test has frequently also a number of secondary orifices, in the form of small circular pores on the face of the terminal segment. The septa are double, and the skeleton is furnished with a system of canals, the general features of which are analogous to that of *Nummulites*.

Locality, Meeker county, Minn.

XXI.

NOTES ON THE MAMMALS OF BIG STONE LAKE AND VICINITY.

BY C. L. HERRICK.

The region about lakes Big Stone and Traverse is interesting not only from a geological standpoint but in its faunal relations. We here find the approximate limit of several distinct faunal areas and are not disappointed in expecting transitional forms and the material for deciding several interesting questions in systematic zoology. It is not the present purpose to anticipate the remarks which may be offered upon this subject in the final report on the *Mammals of Minnesota*, now approaching completion and which will be submitted in September, 1885; but it may be interesting to offer a few facts, which will hereafter be given more in detail, in order to secure, if possible, the co-operation of collectors in accumulating additional data. We shall find, then, in the immediate vicinity of Big Stone lake, species belonging strictly, first, to the plains of the far west, second, to the prairie region of the south and east, and third, to the woodland regions lying north and east. For example, we here find associated in seeming agreement such animals as the mole mouse of the plains, a variety of the common prairie *Vesperimus michiganensis* or Michigan mouse, the Sonora deer mouse (*Vesperimus sonoriensis*), the red-backed mouse (*Erotomys rutilus, gapperi*), the woodland *Zapus hudsonius* or jumping mouse, and, of late also, a few forerunners of the domestic mouse.

The following list embraces all the mammals at present known to inhabit the district in question, with such notes as seemed worthy of record at this time:

1. **Canis lupus,** L. Wolf.

2. **Canis latrans,** Say. Coyote.

3. **Vulpes vulgaris,** Flem. Fox.

4. **Putorius lutreolus,** Cuv. Mink.

5. **Taxidea americana,** Bd. Badger (?).

6. **Mephitis mephitica,** Shaw. Skunk.

7. **Lutra canadensis,** Sabine. Otter (?).

8. **Procyon lotor,** Storr Raccoon.

9. **Antilocapra americana,** Ord. Pronged-horned antelope.

The last occurrence of the antelope on the Minnesota side, of which I could learn, was in 1881, when one was shot six miles north of Brown's Valley, Traverse county.

10. **Vespertilio subulatus,** Say. Brown bat.

In passing over the many granitic and gneissic masses which shoulder their way through the surrounding drift in the immediate valley of the Minnesota river a few miles below Ortonville, the ear is constantly filled with an uneasy clatter, shrill and tormenting in the extreme, and proceeding from numberless bats passing the day in the crevices. It is not often easy to secure specimens, for, even if the hammer dislodges fragments of rock and destroy the retreat, the inhabitants take flight at once even in bright sunshine.

11. **Scalops argentatus,** Aud. & Bach. Prairie mole (?).

12. **Sorex (cooperi,** Baird ?). Western shrew.

Shrews, which in the lack of a special study are referred to this species, are very abundant at Brown's Valley, and in winter are said to become in part domesticated, living about barns and out buildings, much as the domestic mouse (which is not yet found here) does in other places.

13. **Sciurus hudsonius,** Pallas. Red squirrel (?).

14. **Tamias striatus,** L. Chipmunk.

The ground squirrel occurs in the thickets along the lakes, but is not abundant.

15. Spermophilus tridecemlineatus, Mitch.

The striped gopher is excessively abundant and in some seasons causes great havoc in the wheat as well as corn fields. It dwells on the prairie, while the next is equally abundant wherever a denser growth of grass or trees furnishes it a suitable retreat.

16. Spermophilus franklini, Sab. Gray gopher.

This species was found in greater abundance near Brown's Valley than elsewhere in Minnesota. It is entirely without fear and will take a place at the camper's table if unmolested, partaking of fish or fowl with no manner of diffidence.

17. Geomys bursarius, Shaw. Pouched gopher.

Our most earnest endeavors have failed in securing a specimen of *Thomomys* in Minnesota, although we had reason to expect its occurrence. The Geomys of Brown's Valley and Moorhead are typically the above species.

18. Zapus hudsonius, Zim. Jumping mouse.

It was with considerable surprise that the first specimen of this species as yet seen in Minnesota was captured at Brown's Valley in an oasis of the prairie region. The specimen was so unsuspecting that it was easily taken with the bare hand, and must have long lived in undisturbed quiet on the shores of lake Traverse.

19. Mus musculus, L. Domestic mouse.

A few specimens of a very yellow mouse, otherwise resembling the common mouse, were taken on the shores of Big Stone lake.

20. Vesperimus sonoriensis, Le Conte.

With some degree of surprise all the deer mice of the region in question were found to be in size and (less distinctively) coloration identical with the Sonora mouse. Of a considerable series not one has a tail over 2.60 inches, or a hind foot over .87, while the prevailing measurement of the former is 2.40, and of the latter .70. The colors are lighter and less conspicuous than in the deer mouse, and the white parts encroach more upon the

dorsal area, while the brown portion of the tail is a narrow stripe only. Besides these differences, in the whole anterior portion the pelage is sifted over with whitish, giving it a grayish tinge.

21. Vesperimus michiganensis, Aud. & Bach.

This species, which in the eastern part of the state is not abundant, is the most common form along the upper course of the Minnesota river. It appears in a gray, almost varietal, phase quite different in appearance from the eastern examples of the same species.

22. Onychomys leucogaster, var. pallidus, var. n.

A variety of the mole mouse hitherto undescribed is fully treated in the note at the close of this paper.

23. Erotomys rutilus var. gapperi, Vigors.

The red-backed mouse is by no means rare in the copses about the lakes and along the Minnesota river.

[24-25. Both *Arvicola austerus*, Le C., and *Synaptomys cooperi*, Bd., must be found in the region mentioned, or not far from it, but no examples have as yet been found in Minnesota.]

26. Fiber zibethicus, L. Muskrat.

The musquash is nowhere more common than in the prairie pools of the southwest. Were the fur of more than a nominal value the trapper would find profitable employment here. Upon the banks of the Minnesota river well beaten trails show where the animals leave the muddy banks where their dens are made, for the swamps adjacent.

27. Lepus sylvaticus, Bach. Gray rabbit.

This species is excessively abundant in the low ground along the upper Minnesota.

28. Lepus campestris, Bach. Prairie hare.

Quite common in winter, but it is seldom seen in summer. Universally called "jack rabbit."

To the above list which is necessarily only fragmentary, is appended a detailed description of *Onychomys pallidus*.

Genus Onychomys, Baird.

MOLE MICE.

This genus is of particular interest inasmuch as it contains three varieties of mice which, from their inaccessable station and secluded habits have seldom gained admittance to natural history museums, or received the attention of naturalists. This interest is enhanced by the fact that the genus is evidently very closely allied to *Vesperimus* but has developed in a direction entirely different from that group; and its species, externally and in habits, vary greatly from the deer mice. Fossorial prairie or desert animals living largely on insects might be expected to differ greatly from such saltatorial and gramnivorous animals as *Vesperimus* contains.

The mole mice are distinguished from their relatives by the compact arvicoline form, short tail and hind legs, well developed anterior extremities with fossorial claws, and the soft, mole-like character of the pelage. The hasty observer would refer the animal to *Arvicolinæ* rather than to the sigmodont *Murinæ;* indeed Prince Maximilian, who was the first to meet the genus, referred the *O. leucogaster* to *Hypudæus.* As we have specimens of none of the genus except *O. leucogaster*, var. *pallidus*, the reader is referred to the discussion of that variety for a description of the anatomical peculiarities. It seems that in view of the many points of divergence in structure and habits, there should be no hesitation in separating the mole mice generically from the *Hesperomys.*

Onychomys leucogaster, Maximilian. Missouri Mole mouse.

Hypudæus leucogaster, MAXIMILIAN, Reise in das Innere Nord America, 1841.
Mus missouriensis, AUDUBON and BACHMAN, Quad. N. A., 1851.
Hesperomys (Onychomys) leucogaster, BAIRD, Mam. N. A., 1857.
COUES, Proc. Acad. N. S. Phila., 1874; Monogr. N. A. Rodentia, 1877.
Hesperomys leucogaster, MAXIMILIAN, Arch. f. Naturg. xviii, 1862.

The single species thus far found under the genus *Onychomys* has differentiated into three more or less distinct geographical races or varieties. Of these but one is found in Minnesota, and that only upon the western boundary and a very short distance east of it.

The typical form is stated to be restricted to the upper Missouri river region, and is described as follows:

"Color above, grayish-brown, passing into yellowish-red, and

finally into a stripe of fulvous on the sides. Feet, including outer surface of the fore-arm and under surface of the body and tail, white."—*Baird.*

"Beneath, snow-white; above, mouse-brown, with darker dorsal area. Tail twice the hind foot or less; much less than half the head and body. Fore foot more than half the hind foot. Ear about .50 high."—*Coues.*

"The chief distinguishing feature in coloration, as compared with *Hesperomys leucopus*, is the mostly white muzzle."—*Coues.*

The following measurements from No. 7,492, of the National Museum, are selected as fairly illustrating the proportions. Nose to tail, 4.25; tail, 1.65; hind foot, .88; fore foot, .50; nose to eye, .60; nose to ear, 1.00; ear, .50. The skull of a somewhat smaller specimen measured 1.07 (Coues).

Onychomys leucogaster, var. torridus, Coues,

Was founded upon a single alcoholic specimen from Arizona, which differs in having rather larger ears and tail, and smaller fore feet. The colors are warmer. The following is Dr. Coues' diagnosis:

"Beneath, tawny-white (?); above, brownish-fulvous, with no darker dorsal area. Tail about two and a half times the hind foot; almost half as long as head and body. Fore foot half the hind foot. Ear about .75 high."—*Coues.*

Without discussing the characters on which this variety is founded, we may remark that in the only form which we have seen the proportional length of the tail and limbs was found to be subject to considerable variation, and that even while the exact pattern of coloration was maintained. Coues gives the following measurements of the specimen described: "Nose to tail, 3.75; tail, 2.00; hind foot, .80; fore foot, .40; nose to eye, .50; nose to ear, .95; ear, .70.

Onychomys leucogaster, var. pallidus, var. n.

This variety is based upon a series collected near the sources of the Minnesota river and the Bois des Sioux river in Dakota, which differs so completely in coloration from either of the above varieties as to be entirely incompatible with any description as yet given of O. leucogaster; while, at the same time, preserving the essential characters of the species. Upon first encountering the form while encamped on the shores of lake Traverse, the

writer was at a loss to classify his find, for, in coloration and form, it entirely differed from any description or figure known to him. It was at once set down as an Arvicola on the strength of its compact, obtuse form and burrowing habit, although the large ears and a certain vague suggestion in the appearance, hinted at *Hesperomys*. It was necessary to examine the teeth before conviction was reached that we had to do with a hesperomoid type. The mole-like appearance and habit at last furnished memory with the clue, and we recognized our capture as *Onychomys*.

It will be most satisfactory to transcribe the description made in our diary from the recently killed specimen as being quite unprejudiced by thought of comparison with other species.

Description of No. 103, collected July 4, 1885.

"Color nowhere other than black and white or a mixture of the two. Base of fur everywhere ashy gray. Above, black and white most intimately mixed so as to produce the effect of a whitish reflection from black fur, thus resembling a mole. On the sides the white tips are more numerous among the hairs so that the color is lighter, but the fur is so fine that the pelage would not be called grizzled. Under parts very pure delicate white (soft looking) but sparsely sown with the black-tipped hairs. Soles hairy. Tail not distinctly bi-color."

There is a dark ring about the eyes, the white of the lower parts embraces the lips to the nostrils and the muzzle is hoary. The lip is cleft and the fur about this cleft is long and hangs over like a moustache. The fur is close and dense about the small nasal pads. The insides and veins of the ears are silvery white.

The tail is terete and very closely hairy except at the tip which is as naked as in *Geomys*, and is gradually reduced in size from the middle to the apex. The vibrissæ are unusually fine and long, reaching beyond the apex of the ear and are of uncertain color, really black, but so polished as to appear partly white. The sole is very densely covered with fine close hairs, and there are but four tubercles. The ears vary in length, but seem to be intermediate between the varieties above mentioned.

O. pallidus burrows on the sandy prairies and seems to be largely diurnal in habit. We know little regarding its habits, but, inasmuch as its stomach was found filled with the remains of grasshoppers and other insects, we are justified in claiming that the suggestion of a largely insectiorous diet offered by the dentition is borne out by actual observation. The coloration

must be influenced by the constant exposure which a chase of diurnal insects makes necessary upon the open plains; and the short and nearly naked tail are suggestive of the fossorial habits.

The following table gives all the details at command concerning the proportions; and, as all the measurements were made with great care upon recently killed specimens, may be trusted as thoroughly reliable.

No.	Nose to anus.	Tail.	Nose to ear.	Nose to eye.	Hind foot.	Fore foot.	Ear.	Sex.
103	4.60	1.45	1.08	.60	.90	.55	.60	female.
104	4.40	1.35	1.00	.55	.90	.....	.50	male.
105	3.95	1.50	1.00	.50	.80	.40	.....	male.
114	4.15	1.60	.92	.50	.85	.....	.....	male.
115	5.10	1.60	1.20	.60	.90	.50	.....	male.

Osteology of Onychomys pallidus. (No. 105.)

We shall present our material in the form of a comparison of the skeleton with that of *V. leucopus* as the most typical and readily obtainable example of *Vesperimus*. While much resembling that of *V. leucopus*, the skull is heavier and less slender. The facial portion, particularly, is shorter and blunter. The cranial portion is more capacious and shows a greater development of the parietals. Greatest length, 1.40; width, .58; width across parietals, .53; length of nasals, .37; frontals, .31; parietals, .18. The nasals project less beyond the incisors. The prepalatine foramen is much wider than in *V. leucopus*. The molars are larger than in any *Vesperimus*, although the third pair are more diminutive than in the actually smaller *V. leucopus*. The teeth are peculiar, especially for their very sharp-pointed angular prominences, which project out far from the crown of the tooth. The pattern is the same, but the appearance presented is very different. The basis cranii is broader, while the proportion of the parts is otherwise scarcely different. Length of basi-occipital, .16; molar series, 17; width of foramen magnum, .20. The lower jaw is chiefly remarkable for the great development of the coronoid process, which in *Vesperimus* is a minute hook, but here is large and strongly curved, extending nearly as far backward as the condyloid. The angle of the mandible is as in *Vesperimus*.

There are seven cervical, thirteen dorsal, six lumbar, three

sacral, and seventeen caudal vertebræ—forty-six in all. The caudal series measures 1.75, the sacral .36, the lumbar .70, and the dorsal about .90. The scapula is larger in proportion, in harmony with the greater development of the arm in general, but has the same form. Length, .54; width, .26. The humerus is .55 long, and is proportionately much heavier than in *Vesperimus*, but the superiority is more clearly seen in the forearm. The radius is .53 long, while the olecranon process of the ulnar is unusually strong. A general heaviness characterizes the bones of the hand. The hind limb is remarkable for the heavy and short bones composing it. The femur is .70 long, the tibia .75, and the longest metatarsal .30, while in *V. leucopus* these parts measure .60, .80 and .35. In this species only .30 of the fibula is united with the tibia, while in *V. leucopus* nearly .40 of its length is fused. We find, therefore, only a circumstantial confirmation of the view gained by external examination.

NOTE.—Measurements all in inches and decimals.

ERRATA FOR THE GEOLOGICAL REPORT.

Page 66, fifth line from bottom, for *two* read *four*.
Page 71, the first line should be transferred to the bottom of the page.
Page 149, fourteenth line, before *Leidy* insert *to*.
Page 171, seventh line from the bottom, for II read IV.
Page 176, twenty-first line, for II read IV.

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THE

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AND

NATURAL HISTORY SURVEY

OF

MINNESOTA.

THE THIRTEENTH ANNUAL REPORT,

FOR THE YEAR 1884.

N. H. WINCHELL, STATE GEOLOGIST.

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